EFFECTIVE FARMING

SAMPSON

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TORONTO

Art and Science Meet in the Fundamental Farming Operation

EFFECTIVE FARMING

A TEXT-BOOK

FOR

AMERICAN SCHOOLS

BY

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New York

THE MACMILLAN COMPANY
1918

Set up and electrotyped. Published August, 1918.

Norwood Press
J. S. Cushing Co. — Berwick & Smith Co.
Norwood, Mass., U.S.A.

PREFACE

As early as 1824 a text-book of agriculture was published in the United States. This book was an agricultural reader, by Daniel Adams. In 1837 a "Farmer's School Book," by Orville Taylor, was published at Albany and Ithaca, N. Y. For one hundred years there has been pressure for the introduction of agriculture into schools. The subject has waited, however, for many reasons. The industrial development of the middle of the last century undoubtedly obscured the importance of agriculture. The colleges of agriculture were expected to satisfy much of the demand. In the later years of the last century the profits in farming were difficult and small. Schools have been unadapted to teaching in agriculture.

Now, however, the way has opened. A national law of vast significance (The Smith-Hughes Act) has provided the means for redirecting the schools and providing instruction in agriculture and home-making. Many schools have learned to teach these subjects. It is admitted by all that the vocational subjects dealing with land and its produce are essential to any school system that would help maintain the best kind of civilization. Our first duty is to care for the earth. If we cannot produce our supplies for food and clothing, all the other elements of society perish. A text-book of agriculture, therefore, deals not only with an interesting set of subjects but it also strikes at the foundations of human institutions.

No longer shall we feed ourselves by chance or by foraging; the time is rapidly passing when we may longer till the earth carelessly or ignorantly. All the people demand that the farmer shall be intelligent, alert, and resourceful, providing a proper support for society. We cannot live on the past. We

must apply the best knowledge and the shrewdest skill to the soil.

To meet the new demands, many texts are appearing. The present book is one of the contributions to this rapidly enlarging field, drawn from several years' experience as a teacher of agriculture in both high school and college. It aims to present instruction in practical agriculture in such a way as to be readily understood by both pupil and general reader, and to be directly adaptable, at the same time, to the needs of the classroom and laboratory.

Agriculture is a subject of great variety. One person cannot cover it all. As indicated in certain parts of the text, some of the matter has been compiled from publications of the United States Department of Agriculture and the state experiment stations. This form of compilation suggests the kind of valuable information that can be gleaned from these publications. Too few teachers realize the great extent of practical teaching-material in these bulletins and circulars.

In writing a text-book, an author must now call on many persons. Appreciation is expressed to the following individuals, public departments, and firms for aid and for criticism of the manuscript and for many of the photographs used in making the illustrations: L. H. Bailey, C. H. Lane, E. A. Miller, F. E. Heald, W. R. Barrows, M. A. Carleton, Joseph A. Arnold, C. C. Cleveland, A. E. Young, J. E. McClintock, O. C. Peck, G. E. Stayner, P. G. Holden, M. A. Blake, M. B. Waite, John W. Roberts, J. F. Jackson, H. K. Bush-Brown, Charles Gray, J. W. Clise, S. C. Hallock, M. V. Richards; the United States Department of Agriculture, Ohio State University, the experiment stations of Iowa, Illinois, New Jersey, Rhode Island, and Ohio; Cutaway Harrow Company, Emerson-Brantingham Implement Co., International Harvester Co., The Avery Co., Southern Railway, Central of Georgia Railway, Janesville Plow Co., Aspinwall Manufacturing Co., The Deming Co., Thoroughbred Record, Arabian Horse Club, Acme Harrow Co., Moline Plow

Co., American Yorkshire Club, The Country Gentleman, American Jersey Cattle Club, American Guernsey Cattle Club, American Aberdeen-Angus Breeders' Association. Aid from these sources has done much toward making the book more accurate, and more worth while to both pupil and teacher.

I desire, also, to express my appreciation of help rendered by several friends who have read proof sheets of certain of the chapters. Professor W. H. Stevenson, of the Iowa State College, the chapters dealing with soils; Dr. C. W. Larson, of the Federal Dairy Division, the chapters on dairy cattle and dairying; Professor R. S. Curtis, of the North Carolina Agricultural Experiment Station, the chapters dealing with live-stock; Alice V. Wilson, of the East Carolina Teachers' Training School, and Mary Stuart MacDougall, of the Winthrop Normal and Industrial College of South Carolina, the chapter on plant study; and my assistant, Professor Thomas B. Meadows, all of the chapters.

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GENERAL VIEW

Agriculture fundamental.
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VERY interesting and important is the study of agriculture. It is essentially a study of nature. The scene of agriculture is the out-of-doors. It is associated with weather, clouds, sun, and open sky. It is founded on the soil, itself so complex that we do not yet understand it fully; in the soil the changes are involved, due to many chemical reactions, the movement of fluids, and the work of millions of microörganisms, all modified by rainfall, frost and heat, structure, action of roots, manipulation by the farmer, and many other conditions. Every seed is a mystery, containing within itself a living plant possessing wonderful possibilities. Under the proper conditions, this seed grows, the resulting plant bearing stems and leaves and flowers and fruit, all fashioned out of the abundant atmosphere and earth. Many of these plants become the food of animals, and their elements later appear in meat, milk, wool, and in the muscles and the power to pull a load. Constant change is the order of nature; the farmer utilizes these changes in the production of his crops and live-stock. The better he understands them, the greater success and satisfaction should he have in his work.

1. Agriculture fundamental. — Agriculture is the production of plants and animals useful to man, together with the

marketing and other practices that appertain thereto. It is fundamentally the most important occupation, for practically all others depend on it and it is essential to the maintenance of the race. Mining, manufacturing, and commerce would soon cease were it not for the farmer. Not only most of the food, but also much of the material used in manufacturing and the arts is produced out of the land by the hand of the farmer. Garfield has aptly said, "At the head of all sciences and arts, at the head of civilization and progress stands — not militarism, the science that kills, not commerce, the art that accumulates wealth — but agriculture, the mother of all industry, and the maintainer of human life."

2. Agriculture as art, science, and business. — Agriculture is an art, the application of science, and a business. Art has to do with skill gained through practice. Science considers the reasons for all the operations. Biology, chemistry, physics, and meteorology contribute directly to what may be termed the collective science of agriculture. Investigation in the laboratory and the field has yielded much information useful to the farmer and this knowledge, coupled with statements of methods and records of experience, has been arranged and published in books and bulletins which are available for study.

The business side of farming is no less important than the art and science phases. A farmer may be skillful in his farm operations and have good understanding of the scientific principles involved, but may fail on account of lack of business, or commercial, ability. The commercial side involves executive power of a high order in the managing of men, the systematizing of farm work, the purchasing of supplies, the keeping of records and accounts, and the packing and marketing of produce.

Not only should the farmer produce crops and animals, but he should do this effectively, with the least expenditure of time and effort to accomplish a given result. He should maintain the fertility of the land, not only for the production of larger yields for himself, but also for the sake of those who are to come

after him. The farm is an establishment in itself in which the good countryman has pride and into which he puts his best efforts as a man.

Farmers too often live and farm according to rules and methods established by their forefathers, and such persons often fail to profit by the discoveries and methods of modern agriculture. If North America is to maintain its place in feeding and clothing its own population and in adding to the supply of other countries, the farmers of the future must be thoroughly trained to their occupation.

3. Divisions of agriculture. — Agriculture is grouped into crop husbandry, animal husbandry, and agricultural manufacture. Crop husbandry is subdivided into grain-growing, fruit-growing, fiber-crop production, forestry, floriculture, and other branches. Animal husbandry includes dairy production, beef-raising, sheep-raising, swine-raising, poultry-raising, and bee-keeping. The manufacture of agricultural products deals with butter-making, cheese-making, ice-cream making, the manufacture of evaporated milk and evaporated fruits, and the home weaving of cotton and other textiles into thread and cloth. Naturally these groups and subdivisions overlap and individual farmers often produce many kinds of farm crops and manufactured products, and raise live-stock as well. For example, a farmer may be a fruit-grower and a poultryman, a dairyman and a manufacturer of butter and cheese, a grain-grower and a producer of both beef and grain. Or he may be a specialist and produce only one kind of crop. Thus he may be a market-gardener and not grow enough grain to feed his own teams, or a fruit-grower exclusively, or a poultryman who has only a few acres and buys all the feed for his fowls. The scientific principles of agriculture apply equally to many kinds of farming. As examples, the considerations underlying soil improvement relate as well to grain-growing as to fruit or vegetable production, the principles of nutrition are as important to the farmer producing beef cattle as to the dairy-

man, the underlying facts in the control of insects and plant diseases apply over a very wide range of crops.

4. Farm possibilities. — The farmer lives on his farm, developing his home and all its surroundings. This home should be convenient, comfortable, and attractive. He has relation to highways, telephones, mail routes, neighbors, churches, schools, societies, fairs, farm-bureaus, markets, and transportation. All the affairs and activities of the farmers, of their families and helpers, constitute an agricultural life. This life is as important to the nation as the products that the farmers raise. The farmer cannot confine himself within his own fences. He is part of the community and is under obligation to take part in its activities.

The crops and animals are to be of the best. The farmer himself is also to be well reared, well educated, well fed, well clothed. His family is to be provided with a good dwelling, good books and periodicals, good pictures, good music, good grounds and yards. The farm people are to derive the greatest satisfaction from their occupation, not only in money, but in home comforts, in the appreciation of nature, and in the desirable things of life.

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CHAPTER II

PLANT STUDY

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CROPS are the products of plants. In some cases the product is the fruit, as the apple and Indian corn; in others, the root, as turnip and beet; in others, the leaves, as lettuce and tobacco;

in others, the fiber on the seeds or in the stem, as cotton and hemp; in others, the seed itself, as beans and peas; in others, the entire herbage above ground, as alfalfa, timothy, junegrass. In other cases, the product is a manufactured commodity, as sugar. The study of plants is fundamental to the study of crops. One does not understand nature until one knows something about plants. The earth is covered with vegetation; the vacant lot soon becomes covered with weeds. All the plants, of so many thousand kinds, take nourishment from the soil and the air. They live and grow and multiply their kind. We could not live on the earth were it not so. The processes in plant life are therefore very important for us to know before we proceed.

5. Elements and compounds. — Before taking up the study of plants, it will be well to recall a few principles of physics and chemistry. All substances in nature are subject to changes in form and composition. When a piece of iron is broken or crushed the form is changed, but each particle has the same composition as before. This change is physical. If the piece of iron is left out of doors, rust forms on its surface. This is a different substance from iron; it is composed of iron and oxygen, the oxygen coming from the air. Such a change in composition is chemical. The simplest form in which matter can exist is as an element; the chemical union of two or more elements forms a compound. In nature there are only about eighty different elements, but there are many compounds. When compounds or elements mix physically and do not unite chemically, a mechanical mixture is formed. The air is an example of this, as it is made up of oxygen, nitrogen, carbon dioxide, and some other gases, but they are not united chemically.

6. Classes of compounds in plants. — Analyses of plants show many different compounds, but these can be grouped into five classes known as: water, ash, carbohydrates, fat, and protein.

Water in plants. — Water is composed of the elements, hydrogen and oxygen. It not only forms a part of the body of the plant, but carries dissolved food to all parts — root, stem, and leaves — and regulates the temperature of the plant during growth.

Ash in plants. — The mineral matter of plants is the ash. It is that portion that remains after the plant has been burned and includes all the materials, except water and nitrogen, that the plant takes from the soil. The elements in the ash of plants are potassium, phosphorus, calcium, magnesium, iron, sulfur, sodium, chlorine, silicon, manganese, and aluminum.

Carbohydrates in plants. — The carbohydrates are composed of carbon, hydrogen, and oxygen. They include chiefly starches, sugars, cellulose, and pentosans. Starch in its various forms is more or less familiar to all and is found most largely in the seeds, roots, and tubers. Plant-sugar includes cane-sugar, beet-sugar, maple-sugar, and glucose. Cellulose is the fiber of plants. It is found more largely in the stems and leaves than in the seeds. It is neither soluble nor digestible. Pentosans aid the cellulose in giving form to the plant-tissue; they are insoluble in pure water, but soluble in dilute acid. When acted upon by the digestive juices in the animal-body, they are dissolved and are useful as nourishment.

Fat in plants. — In nearly all plants fat is present. It is found more largely in the seeds than in the other parts. Flax, rape, and cotton seeds are rich in fat. The percentage in plants varies considerably. In tubers it is sometimes a few hundredths of one per cent, while in the flaxseed it is thirty-five per cent. Corn is often five per cent fat, wheat two per cent, hay about one and one-half per cent, and straw less than one-half per cent.

Protein in plants. — The term protein is used to designate those organic compounds that contain the four elements, carbon, hydrogen, oxygen, and nitrogen. Some contain phosphorus, sulfur, or iron in addition. Protein is a general term and the number of compounds included in this group is very

large. Because of the presence of nitrogen in all the compounds, they are often termed nitrogenous, to distinguish them from the others which are termed non-nitrogenous compounds. None of the other classes contains nitrogen.

Materials determined by the chemist. — When making chemical analyses of plants, the chemist determines the water, ash, protein, ether-extract, crude-fiber, and nitrogen-free extract. The meaning of the last three terms requires some explanation. Ether-extract is applied to those compounds that are soluble in ether. They are largely fats, but as yet the chemist is unable to determine the quantity of pure fat in all substances. Crude-fiber includes cellulose and some other bodies that make up the frame-work of vegetable tissue. Nitrogen-free extract is composed of compounds that contain no nitrogen and these are largely starch, sugar, and pentosans.

7. Structure and functions of plant parts. — When a very small portion of plant substance is examined under a microscope of high power, it is seen to be made up of a large number of divisions more or less clearly defined. These are called *cells.* In a transverse section they present somewhat the appearance of the cells of a honey-comb, which accounts for the name. The higher plants are composed of many cells of different forms; some of the lower plants consist of but a single cell; others, of a single row of cells. A cell is surrounded by a cell-wall and, in the case of live cells, the interior is a semi-liquid, translucent substance called protoplasm. Growth in plants may occur either by the expansion or by the multiplication of cells, which takes place either by the dividing of old cells into two or more smaller ones or by the forming of new cells within old ones, these new cells in either case enlarging later to full size.

Epidermis and bark of plants. — Succulent parts of plants are covered with a thin skin, known as the epidermis, which extends over the entire surface of the leaves, stem, and roots. This skin is made up of fairly thick-walled cells that protect the more delicate interior parts. In the older stems of woody

plants the epidermis is replaced by bark. Beneath the bark is a layer of cells called the cambium-layer, forming the growing tissue of the plant cylinder.

Minute openings, known as stomata (singular, stoma), are found in the epidermis of the leaves. These openings are extremely small and the number on a leaf is very large; it has been found that more than one hundred thousand are present on the under surface of an apple leaf. The water that passes from the plant as vapor and the oxygen set free in the elaboration of food in the leaves escape from these openings, and carbon dioxide from the air passes into the plants through them.

Function of roots. — The roots have two very important functions. They anchor the plants in the ground and serve to supply them with water in which is dissolved the food that is taken up from the soil. The root system is made up of the main roots and branching parts that penetrate the soil in all directions. On these small branching parts are found tiny root-hairs that penetrate between the soil particles and absorb water containing plant-food, which is carried up into the plant as sap. As many as twenty to twenty-five thousand root-hairs may be present on a square inch of root surface. Each root-hair consists of a single elongated cell. As the end of the root advances through the soil, new root-hairs are formed beyond the older ones and those farther back die.

Water from the soil passes through the cell-walls of the root-hairs by what is known as osmotic pressure. When two liquids of different densities are separated by a semi-permeable membrane, there is a movement of the less dense solution toward the more dense. This is known as osmosis. That liquids move as just described can be proved by tying a piece of pig's bladder that has been soaked in water over the end of a thistle-tube, filling the tube with a sugar sirup until it stands in the neck of the tube, and placing the tube, bell-end down, in the water. A large-mouthed bottle fitted with a cork through which the tube can extend is a convenient receptacle to hold the water.

There will be an exchange of liquids through the bladder, which will be indicated by a rise of the liquid in the tube. In this way water with dissolved plant-food passes into the root through the root-hairs. The walls of the root-hairs are a semi-permeable membrane and the sap in the plants is of greater density than the water solution in the soil. Consequently there is a passing of water and dissolved plant-food into the root.

Function of stems. — In most species of plants the stem is the part that supports the leaves. However, in some kinds, the Irish potato and Bermuda-grass for example, underground stems develop, and in certain cacti the stem and leaves are one.

The parts of a stem where leaf or leaves or other stems are attached are called nodes and the space between adjacent nodes, an internode. Examine several species of plants and locate these parts.

Function of leaves. — The leaves are a very wonderful laboratory where important changes occur. The food that is taken from the soil and carried in the sap and the carbon dioxide that passes from the air into the leaves through the stomata are united chemically in the leaves and form the various compounds of which the plant body is composed. Thus we might think of the leaves as the stomach of the plant. Chlorophyl, the green coloring matter of plants, is necessary in the chemical change that takes place. Chlorophyl forms only in the light. The process by which plants manufacture the food compounds is called photosynthesis.

The changed food material is carried from the leaves to the different parts of the plant where it is used to build up the plant body. In the elaboration of plant-food not all the water absorbed by the root-hairs is required and the surplus and also some uncombined oxygen pass off through the stomata into the air.

Function of flowers. — Flowers are the reproductive organs of the plant. They are classified as complete and incomplete.

A complete flower consists of four parts—calyx, corolla, stamens, and pistils. Cherry, apple, and cotton blossoms are examples of this class. With a complete flower before you, locate the different parts as described here. The calyx is usually green and consists of leaf-like parts, the sepals, surrounding the stem at the bottom of the blossom. The corolla is the spreading part just above the calyx. It consists of the petals, which are often white or bright-colored. Inside the corolla is a group of slender parts called stamens. These are the male organs of reproduction. Each stamen is made up of three parts: the long slender stalk that connects with the stem is the filament (sometimes absent); the enlarged part at the top of the filament is the anther; the yellow dust of the anther is the pollen. Inside the group of stamens in the middle of the flower are the pistils or, in some cases, only one pistil. These are the female organs of reproduction. The parts of a pistil are the ovary, which is at the base of the pistil, and the style, which is the slender part that supports the enlarged flattened summit called the stigma. The ovary contains the ovules that when properly fertilized, as described later, develop into the seeds.

Flowers of certain species vary considerably from those of the apple, cherry, and cotton. The petals may not be uniform in size or may be wanting. Certain parts of the flower, in some species, are lacking; the corolla may be absent; there may be neither calyx nor corolla; some flowers have no stamens; some have no pistils. If stamens and pistils are in different flowers, termed staminate and pistillate flowers, they are known as imperfect flowers. If the staminate and pistillate flowers are on the same individual, the plant is said to be monœcious; if on different plants, diœcious.

The union of the male cell and the female cell in the formation of the embryo of a seed is known as fertilization. This is accomplished after the pollen is carried to the stigma. During a certain period of growth, the surface of the stigma is moist and, if a fertile pollen grain adheres to the stigma at this time,

a slender projection of the pollen-cell penetrates the stigma, passes through it to the ovule, and the egg-cell is fertilized. The fertilized egg-cells develop into the seeds. The distribution of the pollen is called pollination and takes place for the most part by means of the wind or insects. In flowers that are pollinated by the wind, the petals are usually inconspicuous in color, while those pollinated by insects are usually bright in color or fragrant. Why is this?

The buds. — A bud is a condensed body containing rudimentary parts which represent leaves or flowers. Such a body at the end of a twig is a terminal bud, one at the junction of a leaf with the stem is a lateral bud. Under the stimulus of vigorous root pressure, buds may be formed along the internodes. For example a willow cut off early in the growing season will develop buds at the top of the stump; or when trees have been severely pruned water-sprouts may form along the branches; or in the case of a frosted tree a circle of shoots may spring up around the base of the tree. Such buds are called adventitious. In propagation by division of the plant, adventitious buds are often utilized. (See paragraph 10.)

8. **Propagation by spores.** — Spores are the organs by means of which the fungi propagate. They are small seed-like bodies that, under favorable conditions, send out thread-like germinating tubes which, on penetrating a suitable host, draw nourishment from it. Spores differ from seeds because they do not contain an embryo, or undeveloped plant. This method of propagation is not of direct importance so far as the production of crops other than mushrooms is concerned; it is indirectly important, however, because it is the means of reproduction of many of the diseases of higher plants, such as rust, leaf-spot, mildew, and scab. All the so-called flowerless plants, as ferns, mosses, and sea-weeds, propagate by spores. The spore is not usually the direct result of fertilization.

9. **Propagation by seeds.** — Nature's primary method of multiplying the higher plants is by seeds. Nearly all of these

plants produce seeds. However, in farm practice it has been found that some plants can be propagated better commercially by dividing them. (See paragraph 10.) Annual plants such as corn, small grains, and most vegetables are usually propagated by seeds.

In every live seed is the embryo, or germ, which is really a living undeveloped plant. The seed also contains stored-up food material (starch and oil largely) that can be used by the embryo while the seed is sprouting and by the plantlet until it can secure nourishment from the soil and air. When live seeds are placed in a warm, moist, well ventilated soil, they germinate or sprout. They can also be sprouted by placing them between pieces of cloth or blotting-paper and keeping moist and warm. When sprouted seeds are examined, it is seen that the seed-coats have broken and tiny shoots have burst through the opening. The embryo of a seed consists of three parts: the radicle, also known as the caulicle and as the hypocotyl, the part that develops into the root; the plumule, the part that develops into the stem and leaves; the cotyledons (in some species of plants only one cotyledon is present), the seed leaves that nourish the young plant. A sprouted bean (Fig. 1) may be examined to learn the three parts. The slender stem-like part is the radicle, the two tiny leaves between the halves of the bean form the plumule (in the illustration the plumule is shown outside the bean), and the halves of the bean are the cotyledons. When a planted bean grows, the cotyledons are brought above the ground and, as the plant continues to develop, they shrink in size, the stored-up food they contain being used by the plant until it obtains sufficient nourishment from the soil. In some cases the stored-up food is separate from the embryo, as in the corn. A corn kernel in cross-section is shown in Fig. 2. The caulicle, plumule, and cotyledon (corn has one cotyle-

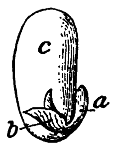

Fig. 1.—A sprouted bean. *a*, **radicle;** *b*, **plumule;** *c*, **cotyledons.**

don) are plainly marked. The stored-up food is called the endosperm.

Conditions necessary for germination. — Moisture, warmth, and oxygen are necessary for the germination of seeds. Live seeds will not germinate if kept dry; they must absorb a certain quantity of water before the seed-coat will burst and the plumule and caulicle emerge. The seeds of different species of plants vary as to the temperature at which they will sprout;

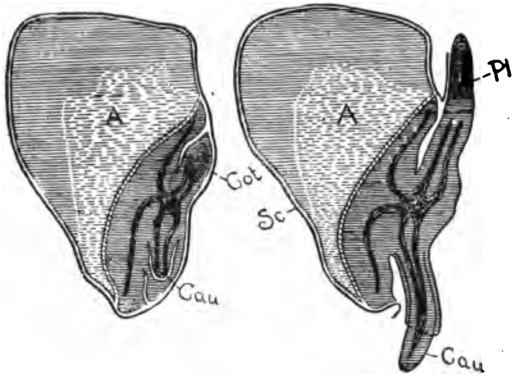

FIG. 2. — Cross-section of a germinating maize kernel. *A*, endosperm; *Cot*, cotyledon; *Cau*, caulicle, or radicle; *Pl*, plumule.

some seeds, like those of the sweet pea, will sprout at a relatively low temperature, while others, cotton for example, require a higher temperature. Seeds will not sprout in a medium that does not contain oxygen. In soil of good tilth air, and therefore oxygen, is present in the spaces between the soil particles. In a soil saturated with water, the air has been crowded out and seeds planted in such soil will not germinate, because of the lack of oxygen.

Storing of seeds. — Seeds should be stored in a cool dry place where they can be protected from rats, mice, and other pests. Both warmth and moisture are to be avoided in a storage house. Warm, moist seeds that are subjected soon after to freezing

are very likely to be injured for germinating purposes. When seeds are dry they can withstand considerable cold. The reason for protecting seeds from pests is obvious.

Quality of seeds to purchase. — The farmer when purchasing seeds should see that they are plump and well filled. Shrunken seeds seldom produce healthy plants. The purity of the seeds must be considered, also, by purity being meant the presence or absence of weed seeds. Small seeds like clover and alfalfa often contain weed seeds and if planted many weeds will grow in the field. The difference between the cost of good and of poor seeds is very small.

10. Propagation of field, vegetable, and greenhouse crops by division. — Some plants propagate themselves naturally by division; others are propagated by artificial means. The extent to which propagation by division is used will be learned from the succeeding paragraphs.

Division of the crown. — Propagation by dividing the crown of the plant is practicable with rhubarb, dahlia, globe artichoke, and a few others. It consists in cutting the crown into two or more parts while the plant is dormant and planting these parts to form new individuals. In the case of rhubarb, which may be taken as an example of a plant propagated by this method, a piece of root containing a strong eye, or bud, will produce a good specimen in one season, but the stalks will not be ready for cutting until the second year. The roots can be cut into as many pieces as there are good eyes, but most growers find it a better practice to allow two eyes to remain on each piece.

Specialized buds. — Some species are provided with specialized buds that can be planted to propagate new individuals. These specialized buds are known as bulbs, bulblets, corms, and tubers. A *bulb* is a very short stem that contains a terminal bud surrounded by scales, the enlargement of the onion plant being an example. *Bulblets* are small bulbs that grow in the axils of the leaves of certain plants, as in the tiger lily, or at

the apex of the stem, as in the top, or bulb-bearing, onion. A *corm* is similar to a bulb, except that it is not composed of scales. The food for the new plant is deposited in the thickened stem. The crocus and cyclamen, flowering plants, are propagated by planting the corms. A *tuber* is an underground stem that is provided with buds, or eyes. The white potato produces tubers and, by planting pieces of these, potatoes are propagated. Each piece should contain at least one eye and most gardeners prefer to plant two. The portion of the tuber planted acts as food for the new plant until it is able to take nourishment from the soil. The parts of the white potato plant are shown in Fig. 3.

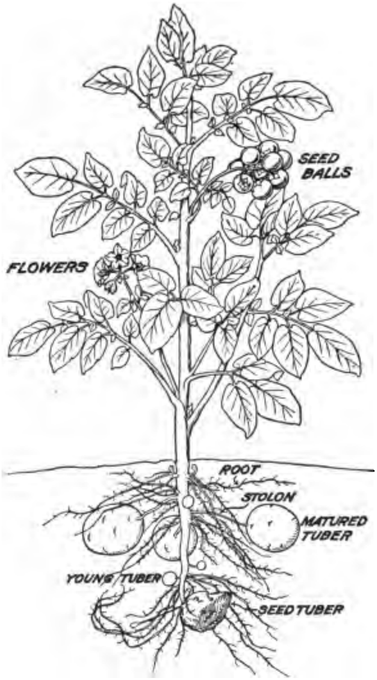

Fig. 3. — Parts of the white potato plant.

Fleshy roots. — Sweet potatoes are usually propagated by placing the roots, or potatoes, in soil in hot-beds. By reason of the heat in the bed, buds form and develop into sprouts and these, called slips or draws, are pulled off and planted. Sweet potatoes also are sometimes propagated by vine cutting, as described later.

Herbaceous cuttings. — Plants such as the geranium, coleus, begonia, and heliotrope are propagated by means of herbaceous cuttings. A cutting is a detached part of the plant that will take root when placed in soil, sand, or water. Later it can be transplanted. Herbaceous cuttings are usually made from the stem with a few leaves attached, but in the case of the

begonia the leaves can be made to sprout. Fig. 4 shows a cutting of coleus.

Sugar-cane is propagated by planting stalks from which the leaves and tops have been stripped. A bud is borne on each node of the stem. When the stem is placed in the soil, these buds will develop into new plants. The buds are easily killed by freezing and for this reason that part of the crop to be saved for planting is harvested early and protected against frost.

Fig. 4. — Cutting of coleus.

Tillers and rootstocks. — Grasses are propagated by means of seeds, but they multiply naturally by tillers and by rootstocks. Timothy, for example, or any grain such as wheat, rye, or oats, which are grasses, multiplies by tillers. Off-shoots called tillers are produced from the lower nodes of a plant and these develop into stalks. Later the new off-shoots produce others and this process continues until the plant becomes mature. This process is called tillering.

In propagation by means of rootstocks the plant sends out lateral shoots, in most species just below the surface of the ground, and these produce at the nodes a set of roots and a stem that forms a new plant. Each of these new plants may in turn send out shoots and produce other individuals. As this process continues, a close sod is formed. Kentucky bluegrass and Bermuda-grass reproduce in this way.

11. Propagation of fruit plants by division. — Most fruit plants are propagated by division and several of them propagate naturally. For example, the red raspberry produces sprouts or suckers that make new plants. The strawberry sends out runners along the surface of the ground that take root, thus producing new individuals. These plants may be cut off and transplanted. The black raspberry produces long drooping canes, called stolons, that take root when the tips

touch the ground. As soon as the stolons have become rooted, the new plant is ready to be transplanted.

The chief method of propagating fruit plants is by division artificially. The means employed are: hardwood stem cutting, root cuttings, layers, grafts, and buds.

Hardwood stem cuttings are made from the ripened wood of the previous season's growth. Grapes, currants, gooseberries, and cranberries are often propagated by means of these stem cuttings. In Fig. 5 are shown cuttings of the grape and in Fig. 6, cuttings of the currant. Hardwood stem cuttings must bear at least one bud and, unless the supply of stock is limited, they are usually cut with two or more buds. Three kinds of these cuttings — simple, heel, and mallet — are used in horticultural practice. A simple cutting consists of a straight part of the shoot or cane, as shown in Fig. 5; it is usually cut off just below the lower bud, since roots develop more readily than when more of the internode is left below the bud. The roots develop from adventitious buds. A heel cutting is made in such a way that a small part of the branch to which the stem is growing remains attached to the cutting, as shown at the right in Fig. 6; this forms what is known as the heel. Obviously one cutting only can be made from the branch and this is a disadvantage, especially if cutting-wood is scarce. However, a heel cutting is somewhat easier to root than a simple cutting. A mallet cutting is similar to a heel cutting, except that the cuts in the parent branch both above and below the attachment are made entirely through the branch, as shown at the left in Fig. 6, thus leaving a section of the parent branch attached to the cutting.

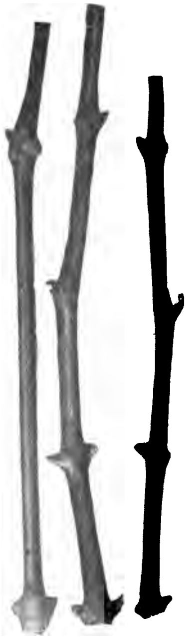

Fig. 5.—Simple cuttings of the grape.

Hardwood stem cuttings are made late in the fall or early in the winter when the wood is dormant. In practice they are tied in bundles of twenty-five to fifty with the butts all one way and usually the bundles are placed butt-end up in a trench in the ground below frost depth and covered with soil. This way of handling keeps the top buds from freezing and places the root ends where they can be warmed by the sun heat in the spring to stimulate root growth. Instead of placing the bundles in the ground, some growers store them through the winter in a cool cellar in sand, sawdust, or moss. Whichever method is followed, in the spring the bundles are taken up, untied, and the cuttings planted about three inches apart in the soil. One or two buds are left above the surface of the ground and the soil is packed firmly about the base of the cutting. If conditions for growth are favorable, the cuttings will start roots and stem during the growing season and will be ready for transplanting in the fall or the following spring.

FIG. 6. — Mallet cutting and heel cutting of the currant.

Root cuttings. — Pieces of roots, usually about the size of a lead-pencil and about three inches in length, are sometimes used for propagating fruit plants. Blackberries and raspberries are often propagated in this way. The cuttings are made in the autumn after the leaves have fallen, and are stored until spring in moss in a cool cellar. When the ground has warmed in the spring, they are planted horizontally about two inches apart and covered with about three inches of soil. By fall or the next spring, they should have developed plants that can be transplanted.

Layers. — A branch or vine that is placed in contact with

the soil and induced to take root while still attached to the parent plant is called a layer and the process of propagating plants in this way is known as layering. Grapes and black raspberries are often propagated by layering. In the case of the grape, this may be accomplished by bending down in the spring a cane of the previous season's growth, laying it in a shallow trench in the ground, partly filling the trench with fine earth, and packing the earth firmly about the cane. About eight inches or so of the end of the cane is left uncovered to supply foliage to keep the vine growing. Sprouts will soon form on the layer and as these grow the trench is gradually filled up. As soon as the new plants are thoroughly rooted, they are detached from the parent plant and transplanted.

Black raspberries are propagated by what is called tip layering. A cane is bent over and the tip covered with about two inches of soil. Roots and a crown of buds that will form a new cane will develop. When the new plant is well rooted, it is separated from the parent plant and set where it is to stand permanently.

Mound layering is a method often employed for propagating currants, gooseberries, and quinces. In the case of currants, the bush is cut back early in the spring to stimulate new growth and early in the fall earth is mounded up around the plants until it covers the new wood. This causes roots to develop on these new canes. Thus a number of new individuals are produced. These may be removed from the parent plant and transplanted the next spring.

Grafts. — When a twig of one tree is fastened to the stem or root of another in such a way that the twig will continue growth from nourishment furnished by the latter, it forms a graft. The twig is known as the cion and the stem or root as the stock. The cambium layers of stock and cion must be in contact. Then sap will be carried from the stock to the cion. This method is employed extensively for apples, pears, quinces, apricots, plums, and others. When propagating apple trees,

seeds are placed in moist sand in the fall or winter to soften them and in the spring they are taken up and planted about an inch deep in rich soil. The ground is thoroughly cultivated during the growing season and in the fall after frost the seedlings are dug up and stored in green sawdust in a cool cellar. Early in November cions are cut from trees of the variety desired to propagate. These should be about six inches long and of the previous season's growth. The cions are packed in sawdust in the cellar and whip-grafted on pieces of seedling root in January or February. In the most usual method followed, the roots of the seedlings are cut into pieces three or four inches long and each piece used as a stock. When making the union of stock and cion, a slanting cut is made on the upper end of a piece of root and a similar cut on the base of a cion. Both the root and the cion are split about an inch down, as shown in Fig. 7, *a* and *b*, and the two are fitted together, as shown in *c*. The two must fit snugly and the cambium layers must be in contact, on one side at least. The graft is then wrapped with waxed cotton (see page 28) to hold the two parts firmly together. The finished grafts are packed in sawdust in the cellar until spring and, as soon as the soil has warmed up, they are planted in the nursery or garden. One bud only is left above the surface of the ground. The ground is cultivated during the summer and by fall the grafts should be large enough to be set in the soil where they are to stand permanently. However, if not needed for immediate planting, they may be grown in the nursery for another year. A better practice is to use whole roots rather than pieces of roots for stocks.

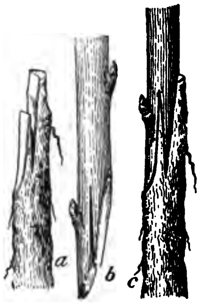

Fig. 7.—Whip-grafting. *a*, the stock; *b*, the cion; *c*, stock and cion united.

Grafting is often employed for top-working apple trees when it is desired to change the variety or have more than one variety on a tree. The cions are set into the branches of the tree.

The usual way of top-working is to cleft-graft, which method is herewith described. In late fall or early winter cions of the previous season's growth, bearing two or three buds, are cut from trees known to be producers of good fruit of the variety desired and are stored in sand or sawdust in a cool cellar where they will remain dormant. The grafting is done in the spring before growth starts. A branch to be grafted (usually one about an inch and a half in diameter) is sawed straight across, care being taken not to loosen the bark. The stub is split with a grafting tool, as shown in Fig. 8, *a*, or with a chisel and a cion cut to a wedge shape with one edge thicker than the other is set into the stock, as shown in Fig. 8, *b*, with the thickest edge toward the outside. This method of cutting and fitting the cion holds it firmly in place. In order to be sure that the growing tissues are in contact, it is well to set the cion at a slight angle; the cambiums of the cion and the stock must then cross at some point. Two cions are inserted in each cleft, as shown in *c*. After they are in place, the grafting tool is removed and all the cut surfaces are covered with soft grafting wax which, when it cools, hardens and forms a covering over the wood. (See page 28.) Later in the season, if both cions are found to be growing, the one showing less vigor is removed. Only a part of a tree should be top-worked because if too many branches are removed not enough foliage is left to nourish the tree. The remaining branches are removed the next year or two.

Fig. 8. — Cleft-grafting. *a*, splitting the stock; *b*, cion; *c*, cions inserted in the cleft.

Buds. — Budding is similar to grafting except that a live bud instead of a cion is placed in contact with the cambium

layer of the stock. Peaches, cherries, oranges, and several other fruits are propagated by budding. The method of growing and budding peach seedlings as given in the following paragraphs will serve to explain the process.

At the close of the ripening season peach pits are secured and either stratified or planted at once. Seedling pits are preferable, as trees grown from them are more hardy than those from the pits of cultivated varieties. However, the latter are often used. In stratifying pits, a well drained spot in the garden or nursery is chosen, the soil removed to a depth of five or six inches, and a layer of pits about an inch or so thick spread over the bottom of the bed. The layer of pits is then covered with a layer of soil about an inch or so thick and a second layer of pits is spread above this and covered with soil. If conditions are favorable during the winter, the pits will keep moist and the frost will break the shells at the suture. In the spring the pits are dug up and the kernels separated from the shells. Any pits that have not opened are cracked and the pits removed. As soon as the ground is dry enough to work, the kernels are planted in rich well drained soil in rows four feet apart with the pits spaced two or three inches apart in the row and they are covered with about three inches of soil. During the growing season the young plants are cultivated frequently and some time in the summer they are thinned to stand about six inches apart in the row. By August they are about half an inch in diameter at the base and are then ready for budding.

If the pits are not to be stratified, they are planted during the fall in the nursery or garden where they will grow, but they are dropped about an inch apart. The frost will open some of them, but not all, and the thicker planting is made to insure a good stand. In the spring the plants that grow are thinned to stand about two or three inches apart in a row and in the summer they are thinned to stand about six inches apart.

Preparatory to budding the seedlings, bud-sticks are cut from

FIG. 9.—Bud-stick.

trees of the variety desired to propagate. Bud-sticks are from twigs of the current season's growth. The leaves are removed, but the petioles are left attached to the twig, as shown in Fig. 9, to act as handles to the buds to aid in inserting them underneath the bark of the stock. In cutting a bud, the bud-stick is held in one hand with the proximal end — the one that was nearest the limb from which the twig was cut — away from the body and a bud is cut by starting about half an inch above the bud and finishing about half an inch below. At the lower end of the cut, as shown in Fig. 10, the bark is left attached until the bud is needed. All the buds are cut before starting to insert underneath the bark of the stocks. The cuts in the stocks are made about three inches above the ground. A cross incision and a longitudinal incision are made through the bark of the stock, as shown in Fig. 11, *a*, and the bark turned back by means of the knife, as shown in *b*. A bud is removed from the bud-stick by cutting it off at the lower end and inserting it underneath the

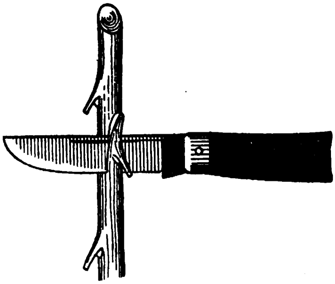

FIG. 10. — Cutting the bud.

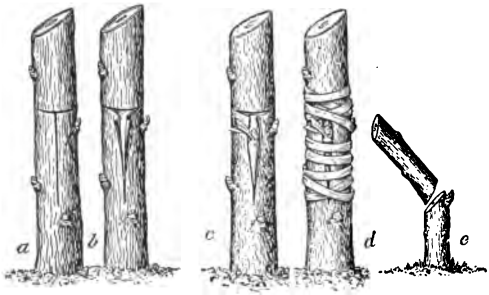

FIG. 11. — Preparing the stock and inserting the bud. *a*, incision made in the bark; *b*, the bark turned back; *c*, the bud inserted; *d*, the bud wrapped to the stock; *e*, the seedling tree removed above the bud.

bark of the stock, as shown in *c*. The cambium layers of stock and bud must be in contact. The bud is then wrapped to the stalk by means of raffia or waxed-string, as shown in *d*. To hold the raffia in place, the ends are pushed underneath the wraps. Waxed-string will stick without tying. In about three weeks, if the bud has set, the raffia or the string must be cut or it may girdle the tree. If sprouts form on the stock, they should be rubbed off, as they use the plant-food that is needed to develop the new bud. The following spring after growth starts, the seedling tree above the bud is cut off, as shown in *e*. Frequent cultivation of the soil during the spring and summer is necessary to keep the young tree growing. In the fall or the next spring, the budded trees are ready to be transplanted to the place they are to occupy in the orchard. Fig. 12 shows a budded tree that is ready for transplanting. Locate the bud union.

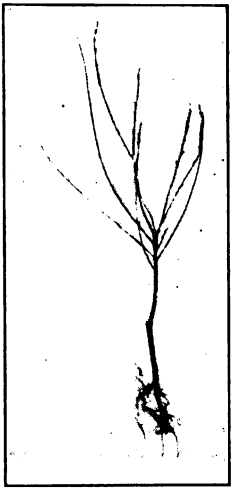

Fig. 12. — A budded nursery tree.

The branches of mature peach trees can be budded in the same way as outlined for seedlings. This is often done when it is desired to change the variety. In this case, the limbs are cut to stubs so that new shoots will arise into which the buds are set.

Apples are extensively propagated by budding in the nursery row. The salable tree is two or three years old from the buds. Pears, plums, and other trees are similarly propagated.

List of commercial methods in fruit propagation. — A list is given below as a convenient guide to the commercial methods used in propagating fruit plants. It will be seen that some plants can be propagated in several ways. All of the methods listed for each plant are employed commercially.

Apple — grafts or buds on seedling apple roots.

Pear (standard) — buds or grafts on seedling pear roots.

Pear (dwarf) — buds or grafts on quince roots.

Quince — buds on Angers quince, grafts on apple roots, mound layers, hardwood cuttings.

Peach — buds on peach seedlings.

Cherry — buds on cherry seedlings.

Plums — grafts or buds on peach, apricot, almond, or plum seedlings.

Grapes — hardwood cuttings, layers, grafts on grape seedlings.

Fig — hardwood cuttings.

Citrus fruits — buds on citrus seedlings.

Strawberry — runners.

Red raspberry — suckers, root cuttings.

Black raspberry — tip layers.

Blackberry — suckers, root cuttings.

Dewberry — tip layers.

Currant — hardwood cuttings, mound layers.

Gooseberry — hardwood cuttings, mound layers.

QUESTIONS

1. What are the functions of water in plants?
2. What are carbohydrates?
3. The term protein is used to designate what kinds of organic compounds?
4. In what three ways are plants propagated?
5. Define spore and tell how spores differ from seeds.
6. What is the embryo of a seed?
7. State the conditions necessary for the germination of seeds.
8. How is rhubarb propagated?
9. Tell how to secure sweet potato slips.
10. What is a cutting? How are cuttings made?
11. Give examples of plants that propagate naturally by division.
12. What time of the year are hardwood stem cuttings made?
13. Tell how blackberries are propagated by root cuttings.
14. Describe the method of layering grape vines.
15. Define graft, cion, stock, bud, bud-stick.
16. How does budding differ from grafting?

EXERCISES

1. **Water in plants.** — Cut a white potato into pieces and observe the water on the cut surface. How did the water get into the plant? Place a small quantity of chopped hay in a test tube and heat slowly. Why does moisture gather around the top of the tube? Try the same experiment with flour and starch. Where does the moisture come from?

2. **The seeds of plants.** — Soak a few beans in water for about an hour. Remove the seed-coat and find the germ and the cotyledons. Make a seed-tester by placing pieces of moist cloth between two dinner plates, as shown in Fig. 13. Place bean and corn seeds in the tester. Keep the cloth moist and the tester in a warm place for three or four days. Examine the seeds after they are sprouted and locate the radicle, the plumule, and the cotyledons or cotyledon. After the roots of the corn have become several inches long, examine them carefully and compare with Fig. 14.

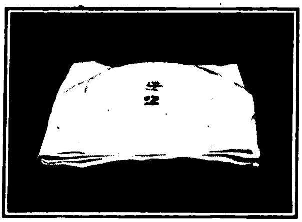

Fig. 13. — A practical seed-tester for small seeds.

3. **Conditions necessary for germination.** — Arrange four seed-testers like the one shown in Fig. 13 and place seeds in them. Label them 1, 2, 3, and 4. Keep tester No. 1 moist and put it in a warm place. The seeds are warm, moist, and supplied with oxygen (air is present between the pieces of cloth) and if they are alive they will sprout. Do not moisten the cloth in tester No. 2, but put it in a warm place. The seeds are warm and supplied with oxygen, but they are not moist and will not sprout. Keep tester No. 3 moist and place it in an ice-box. It is supplied with moisture and oxygen, but not warmth; the seeds will not sprout. Keep the seeds in tester No. 4 covered with water, and place the tester in a warm place. By keeping the seeds covered with water you have practically cut off the oxygen supply and, as a result, the seeds will not sprout.

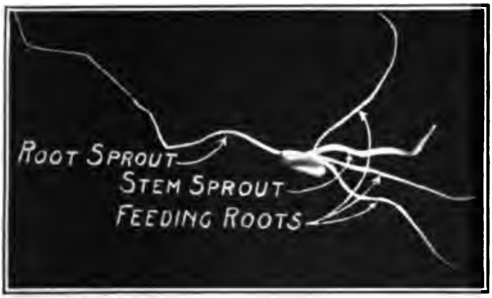

Fig. 14. — Parts of a sprouted maize kernel.

Place soil in a tin can or glass tumbler; plant seeds in the soil and keep the soil saturated with water. At the same time, plant seeds in soil in a flower pot or other receptacle that is provided with drainage and keep the soil moist, but not too wet. Explain the difference in results of the two plantings.

4. **Grafting-wax, waxed-string, and waxed-tape.** — Grafting-wax is used to cover the cut surfaces in cleft-grafting; it forms a protective covering impervious to moisture. Waxed-string and waxed-tape are used for tying buds to the stock in budding and also for holding the stock and cion together in whip-grafting.

The following equipment is required to carry out this exercise. Two pounds of resin, one pound of beeswax, half a pound of tallow or half a pint of linseed oil, small quantity of tallow for greasing the hands and coating the paper in which the wax is to be stored, vessel in which to cook the ingredients, ball of No. 18 cotton yarn, and a piece of muslin.

To make the wax, break the resin and beeswax into small pieces and place them with the tallow or linseed oil in the pan and over the heat. When melted pour the contents of the pan into cold water and when cool enough pull as you would taffy until the wax becomes light-colored and smooth-grained. Rub a little tallow on your hands to prevent the wax from sticking to the skin. Coat some paper with tallow and wrap the wax in this paper and store in a cool place for future use.

To make waxed-string, drop the ball of No. 18 cotton yarn into melted grafting-wax and leave it there for about five minutes. Remove and allow it to cool. Store for future use.

Waxed-tape is made of cloth coated with wax and torn into strips about one-third inch in width. It is used more largely in citrus-tree budding than in the propagation of other kinds of trees. To make waxed-tape, dip a piece of muslin of convenient size into hot grafting-wax, take it out immediately, and scrape off the surplus wax before it cools. A convenient way to do this is to throw the piece of muslin over a stick held horizontally by one of the pupils, then scrape off the wax by pulling downward with two pieces of wood pressed against each other, one on each side of the folded strip. After the surplus wax has been removed, lay the muslin out to cool and, when cool, tear into strips about a third of an inch wide. Wind these strips into a ball and as each strip is added slip the end of it about a half inch under the one previously added. The ends will stick together and the tape will be in a continuous strip, which arrangement is convenient when budding the seedlings.

5. **Propagation by division.** — In the winter secure a rhubarb root, cut it into pieces allowing two eyes to a piece, and plant the pieces in a window-box in the schoolroom. Watch the growth of these pieces of roots. Where does the plant-food that nourishes the plants come from?

Wrap an Irish potato in moist cotton or sphagnum moss. Keep in a warm place in the schoolroom and watch results.

Make cuttings of geranium, coleus, begonia, and heliotrope and plant them in coarse sand that is kept moist and warm. When rooted notice the place on the stem where the roots start. From what kind of buds do they start?

On a field trip observe suckers of red raspberries, stolons of black raspberries, and runners of strawberries. Secure rooted cuttings of these plants and plant them in the school garden.

Following directions previously given, propagate grapes and currants by simple cuttings, blackberries and raspberries by root cuttings, grapes by layers, black raspberries by tip layers, apples by planting seeds and grafting the seedlings, and peaches by planting pits and budding the seedlings. Also, top-work a few branches of an apple tree by means of cleft-grafts and a peach tree by buds.

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CHAPTER III

SOILS

Constituents of soil.
Formation of soil.
Classification of soil according to mode of formation.
- Residual, cumulose, colluvial, alluvial, marine, lacustrine, glacial, æolian.

Classification of soil according to texture.
- Clay, silty, sandy, gravelly, stony, loam.

Classification of soil according to rainfall.
- Humid, arid, semi-arid, semi-humid.

Heavy and light soils.
Structure of soil.
- Separate-grained, puddled, granular.
- Conditions affecting soil structure.

Functions of water in soil.
Forms of water in soil.
- Hygroscopic, capillary, gravitational.

Control of soil-water by cropping methods.
- Reducing run-off losses.
- Reducing percolation losses.
- Reducing evaporation losses.
- Improving soil structure to increase soil-water.

Irrigation.
- Overhead irrigation.
- Sub-irrigation.
- Flooding.
- Furrow irrigation.

Soil drainage.
- Open-ditch drainage.
- Underdrainage.

Air in soil.
Bacteria in soil.

No people can be permanently prosperous and progressive unless it thoughtfully cares for its soil. It is out of the soil that the agricultural products come, for even the fish that the

farmer raises in ponds and streams could not persist were it not for the yield of the land. When the barns are bursting with great yields, the land is to be praised. We are not to think of soil as mere dirt, beneath our notice. The farmer buys his land and cares for it; the more knowledge he has of it the better should be his practice. The proper care of the soil is perhaps his first duty. He must understand tillage and the reasons for it. The robbing of the land of its fertility is not only poor farming for the present, but it destroys the heritage of the future, impoverishing those who come after us. A farmer should not leave worn-out land to his children; and the children are to learn how to care for it, to be ready when it comes their time to have control.

12. Constituents of soil. — From the farmer's standpoint, that part of the earth's crust in which roots can or do find a place to grow is soil. It is composed of broken-up rock particles mixed with animal and vegetable matter. The rock particles are known as mineral matter; the animal and vegetable substances, as organic matter. The particles are of various sizes and shapes and of different stages of decomposition; some are hard and resistant to decay; some are so decayed that they are easily broken. When the organic matter of soil decays until it loses all trace of its original structure, it forms what is called humus. We shall read much about humus in the following pages, for soils without sufficient humus are practically worthless. Humus enriches the soil, makes it darker in color, helps to make it crumbly and easy to cultivate, aids in holding water for the use of the plants, and improves the soil structure.

In addition to mineral matter and organic matter, water, air, bacteria, and plant-food are essential constituents of productive soil. These are discussed in detail later.

The term surface soil is applied to the top layer of soil and subsoil to that layer just beneath it. The top soil contains more humus than the subsoil, is darker in color, more porous, and can be worked into garden condition more easily. The

subsoil usually contains a relatively small percentage of humus; consequently it is somewhat light in color.

13. Formation of soil. — Geology teaches that the earth was once a molten mass, that it gradually cooled and formed solid rock. From this solid rock the soil has been formed by various weathering agents that have been at work for ages. The time element is a very important factor and should be kept in mind constantly when considering soil formation. The chief weathering agents responsible for rock decay are the atmosphere, heat and cold, intermittent freezing and thawing, glaciers, water, and vegetation.

14. Classification of soil according to mode of formation. — The materials of which a soil has been formed are either sedentary or transported. Sedentary materials have not been shifted far from the place of origin. Most transported materials have been moved a considerable distance by such agencies as gravity, water, wind, and glaciers. Consequently according to their mode of formation, soils are either sedentary or transported. Each of these groups is divided as follows:

Sedentary Soils:	*Transported Soils:*
Residual	Colluvial
Cumulose	Alluvial
	Marine
	Lacustrine
	Glacial
	Æolian

Residual soils. — Those soils that were formed in their present locality from the disintegration of rocks are residual. The rocks found underneath them are like those from which the soil has been made. These are the oldest agricultural soils in the United States. They are found in the eastern and central parts and include the Piedmont Plateau, the Appalachian Mountains, the Limestone Valleys, and the Great Plains regions.

Cumulose soils. — Peat bogs and muck soil areas are cumu-

lose. They are found in areas varying from a fraction of an acre to thousands of acres. Any basin that contains standing water throughout the year is a favorable place for the formation of cumulose soil. The vegetation grows, dies, and is covered by the water. The water, shutting out the air, prevents rapid oxidation and, as a result, the organic matter is largely preserved and collects from year to year. The soil that eventually forms is very high in organic matter. Muck soil is in a more advanced stage of decomposition than peat. When drained, areas of muck soil often are of immense value for certain crops, especially celery, onions, and lettuce.

Colluvial soils. — Fragments of rocks and soil that are carried to the base of cliffs by the force of gravity make up the colluvial soils. Their area is small and the soil is usually shallow and unproductive. They are found only in mountainous or very hilly regions and as farm soils are not important.

Alluvial soils. — Along nearly every stream water-deposited soil can be found. This is alluvial. The power of a stream to carry sediment varies with the rate of flow, the more rapid the flow, the larger the particles that can be carried. If the flow of the stream that is carrying sediment is checked, some of the sediment is deposited. When the river-beds are relatively steep, deposits are usually narrow ribbons of coarse sand or gravel. When the bed becomes less steep, the deposits are wider and of finer material. Much humus is washed into alluvial deposits and soils of this type are usually rich, of good depth, and valuable for farming.

Marine soils. — Along the seashore, deposits of varying thickness are made. When such deposits are elevated above the sea, a condition that is often found, they are given the name, marine soils. Most of these are sandy and are largely used for vegetable-growing. Marine soils in the United States extend along the Atlantic and Gulf Coastal Plains.

Lacustrine soils. — Sediment which has been deposited in lakes may later, by the drying up of the lake, become soil.

Such lake-formed soils are known as lacustrine and are of two kinds, those made by recent lakes and those by glacial lakes. Large deposits of glacial lake-formed soils are found in the United States. The fertile Red River lands in Minnesota are largely of this soil. The recent lake deposits are formed when the lakes are filled by river sediment. The area of such soils in the United States is small. Lake-formed soil is usually rich in humus, fine, and of good tilth.

Glacial soils. — The soils that were formed by the glaciers that covered the continent in prehistoric times are usually rich, fertile, of good tilth, and produce good crops. They extend over several of the best farming states, including parts or all of Montana, North Dakota, South Dakota, Iowa, Illinois, Wisconsin, Michigan, Minnesota, Indiana, Ohio, Pennsylvania New York, and the New England States. Much of the corn-belt is glacial soil.

Æolian soils. — Those soils that have been deposited by the action of the wind are called æolian. The principal agricultural soil of this kind is loess, which is generally thought to be wind-blown material from accumulation of sediment carried and deposited by rivers in front of the prehistoric glaciers. Loess is found in great abundance in certain areas of the Mississippi, Missouri, and Ohio valleys. It is very rich and in the Central States is especially valuable for corn-growing.

Sand dunes are wind-blown hills that are not valuable for farming purposes. They are coarse-grained, contain little organic matter and are constantly shifting from place to place.

15. Classification of soil according to texture. — By texture is meant the size of the soil particles. These vary from those that are invisible without the microscope to large rock fragments. Even a fine-grained garden soil is made up of several sizes of particles, which may be proved by stirring a small quantity in a tumbler of water and allowing it to settle. The coarser particles will settle at the bottom; and the finer above them; the very finest may not settle for several hours.

Often there is a distinct banding of the layers of the different-sized particles.

The particles of soil are designated according to size as clay, silt, sand, gravel, and stones. Scientists, for the purpose of making mechanical analyses of soils, have given arbitrary sizes to the various groups of soil materials and have found ways of determining the proportion of each of the different groups in soil samples. The Bureau of Soils of the United States Department of Agriculture uses the following sizes:

Clay — below .005 millimeter
Silt — .05 to .005 millimeter
Very fine sand — .10 to .05 millimeter
Fine sand — .25 to .10 millimeter
Medium sand — .5 to .25 millimeter
Coarse sand — 1 to .5 millimeter
Very coarse sand — 2 to 1 millimeter

In classifying soil according to texture, the same general terms are used as in designating the size of particles. Thus soil composed of a large proportion of clay is known as a *clay soil*, one made up largely of silt is a *silty soil*, one that is mostly sand is a *sandy soil*. *Gravelly soil* and *stony soil* are those with a predominance of these materials. The term loam is used also in describing soil texture. A *loam soil* is one in which fine and coarse particles are about equally distributed. If one size of particle predominates, for example fine sand, this name is prefixed.

The texture of the soil cannot be modified by the farmer to any marked extent. Of course by mixing particles of different sizes together he can make a soil of different texture, but this is not practicable. The farmer, however, should study soil texture in order to determine the best utilization that can be made of each kind of soil. For example, it has been found that fine sandy loams are good trucking soils and that rich loam soils are usually well adapted to corn.

16. Classification of soil according to rainfall. — The terms humid, arid, semi-arid, and semi-humid are employed to indicate the relative quantities of rainfall in localities, and these same terms are applied to the soils. A *humid soil* is one that receives on an average thirty inches or more of rainfall in a year; an *arid soil* is one that receives less than ten inches; a *semi-arid soil* is one that receives from ten to twenty inches; and a *semi-humid soil* is one that receives from twenty to thirty inches. The amount of rainfall naturally influences the crop production of a region, but as some soils do not have the property of retaining much water, it is also necessary that the rainfall be distributed over the growing season, if crops are to prosper.

17. Heavy and light soils. — The terms heavy and light, when applied to soils, refer to the ease with which they can be tilled, not to their weight. A soil that is hard to work and is sticky when wet is known as a heavy soil; one that is easy to work and not sticky when wet is a light soil. Clays, clay loams, and muck soils are heavy; sands, sandy loams, and loams are light soils.

18. Structure of soil. — The term structure refers to the arrangement of soil particles, that is, the way they fit together. It is influenced not only by the texture, but also by the tillage the soil receives, by the quantity of moisture and humus in the soil, by the use of lime, and by the freezing of water in the soil. Three kinds of soil structure — separate-grained, puddled, and granular — are recognized.

Separate-grained structure. — In a soil having a separate-grained structure, each particle exists free and does not cling to adjacent particles; this condition is found in coarse, sandy soil.

Puddled structure. — A puddled condition exists when a heavy soil becomes so packed when wet that the fine particles nearly fill the pore spaces between the coarse particles. The working of a heavy soil or the tramping of it by live-stock when it is wet causes it to become puddled. A puddled soil after it dries

remains in hard clods that are difficult to reduce in size. The tilth of a heavy soil is often spoiled for a whole season or even longer by working it when it is too wet.

Granular structure. — In a soil having a granular structure, the particles are cemented together in small grains. A fine-grained soil with this kind of structure is easily brought into good tilth. A loam soil is usually of a granular structure.

Conditions affecting soil structure. — The operations of tillage have much to do with the structure of soil. The use of tillage implements tends to pulverize soil and to reduce it to a granular condition, provided the work is done when the soil contains the proper proportion of moisture. Notice the pulverized condition of the soil shown in Fig. 15. As stated previously, if a soil of fine texture is tilled when it is too wet, a puddled structure results. Also, a heavy soil, if plowed when it is too dry, does not pulverize well, but is likely to remain cloddy.

Heavy soils, if subjected to alternate wetting and drying, become granular. The alternate expanding and contracting that occurs causes the soil to break into lines of fracture in all directions and this aids in the formation of the much desired granular structure.

The proportion of humus in a soil has an influence on the structure. Humus is somewhat plastic and tends to bind the soil particles together; in the case of a clay soil this helps to form a granular structure.

Lime benefits the structure of a clay soil. It has a flocculating action, that is, the drawing together into granules of the fine particles of a soil mass. If quicklime is placed in water that contains soil particles in suspension, there is a change in arrangement of the particles. At first they draw together in groups that soon settle to the bottom of the vessel. This is flocculation. It occurs when lime is placed on a field and is one of the beneficial effects of such an application.

Freezing and thawing of water in the soil influence soil

structure. The expansion of water when freezing is very great, and this force shatters clods of the soil, tending to promote a granular structure. Repeated freezing and thawing further break up the soil masses. A puddled soil is much benefited

Fig. 15. — The plow is an efficient agent for pulverizing the soil.

by a good freezing. In fact when a soil is puddled in the growing season, it is often impossible to get it into good condition until after a heavy freeze.

19. Functions of water in soil. — Water acts as a solvent of plant-foods. These must be in solution to be absorbed by

plants. Water is taken up by the roots and either becomes part of the plant without change or it is decomposed and the elements of which it is composed are available to become part of new compounds of the plant body. In addition water keeps the cells distended, transfers food from one part of the plant to another, and by evaporation from the leaves tends to equalize the temperature of the plant.

Soil moisture is one of the limiting factors in crop production, for without sufficient water there can be no profitable crop growth. The quantity of water required by a growing crop is much larger than might be thought. The soil solutions taken up by roots are very dilute; consequently large quantities of water must be carried up into the plant for every pound of growth produced. In fact it has been found that in humid climates from two hundred to five hundred pounds of water are transpired from the leaves for every pound of dry plant material produced in a crop. In addition to the water taken up by the plants, there is much lost from the soil by run-off from the surface, by percolation to a depth below the reach of roots, and by evaporation from the surface. These conditions make it necessary in most sections to conserve the soil moisture.

20. Forms of water in soil. — Water is held in the soil in three forms, known as hygroscopic, capillary, and gravitational water.

Hygroscopic water. — This water is held as a very thin film around each soil particle; it is absorbed from the air and condensed on the surfaces of the soil particles. Even in very dry soil, this film-water surrounds each particle. The quantity increases according to the moisture-content of the air and there is more in fine-grained than in coarse-grained soil, because of the larger area of film-surface exposed. Also, the more humus in a soil, the greater is the quantity of hygroscopic water present. The moisture held hygroscopically in a soil cannot be absorbed by plants. In fact plants wilt for lack of water if only hygro-

scopic water is present. However, it is of some use in holding plant-food in solution.

Capillary water. — As soon as the film of hygroscopic water is satisfied, a film of capillary water begins to form around the hygroscopic film and, as the moisture-content increases, capillary water moves from place to place in the soil in the same way that oil is carried through a lamp-wick. It occupies much of the pore space in the soil and moves in every direction, up, down, sidewise, from a wet portion to a dryer portion. When moisture is used by roots or is evaporated from the surface, capillary water moves to take the place of that removed. Capillary water may be defined as that water in the soil that moves from place to place by capillary force. It is the form of water taken up by roots; consequently in productive soils it is necessary that abundant capillary water be present and that the soil be kept in a favorable condition for its transference.

Gravitational water. — If the moisture-content of a soil is increased beyond a certain amount, a point is reached where the force of gravity on the soil-water is stronger than is the capillary force and, as a result, drops of water move downward. This movement is known as percolation and the water when it fills all the spaces is known as gravitational. Below a certain level, the soil is saturated with water. The distance of this water-level below the surface is determined by the rainfall, the condition of drainage, and the kind of soil. The top of the water in surface wells is the top of the gravitational water. Whenever capillary water becomes deficient, water from the water-level, unless this is too far below the surface of the soil, passes by capillary force to the dry portion.

Water in percolating to the water-level carries much soluble plant-food out of reach of the roots. This is known as leaching and it is responsible for the loss of much plant-food annually. If the water-level is very near the surface, there is too limited a zone left for capillary water and growth cannot continue. The remedy for such a condition is drainage.

21. Control of soil-water by cropping methods. — As may be inferred from the foregoing statements, the control of water is an important factor in keeping soil in the best condition for profitable crop production. The farmer can increase water for crops by reducing the loss due to run-off and to percolation, by reducing the quantity evaporated from the surface, and by improving the structure of the soil, thus making it possible for the soil to retain more water.

Reducing run-off losses. — When land is rather impervious to water and in regions of heavy rainfall, the amount of water lost by run-off from the surface may be excessive, if proper

FIG. 16. — A badly washed field.

precautions are not taken to reduce it. The loss is occasioned largely by the water not entering the soil. One remedy is proper cultivation. If the surface of the soil is hard and compact and all tillage operations are shallow, there is less opportunity for water to enter than if the surface is loose and the soil has been cultivated to a good depth.

On hilly land the quantity of water retained can be influenced by laying the furrows to encircle the hill, thus making it possible for the water to be retained on the surface until much of it has time to soak into the soil. This is known as contour plowing. In sections in which the soil washes readily, terraces, which are low ridges of earth encircling the slope at nearly a perfect level, are made on the slopes. Along these terraces

the flow of water is decreased, consequently it has more time to soak into the soil. Moreover the decreased flow tends to lessen the amount of surface soil washed from the field. In many sections of the United States, the lack of proper terracing results in excessive soil washing, which becomes so serious in neglected or improperly farmed areas as to ruin fields. The result of excessive soil washing is pictured in Fig. 16.

Reducing percolation losses. — The loss of water and soluble plant-food by percolation is greater in sandy soils, especially if they have an open subsoil, than in those of finer texture. To prevent this loss, the surface should be compacted with a roller or a subsurface packer. This has a tendency to reduce the rate of percolation of the water. It also reduces the size of the pore spaces, which increases the water-holding capacity of the soil.

Reducing evaporation losses. — In humid climates it has been found that evaporation during the summer months may be as great as seventy-five per cent of the rainfall. This excessive loss of water can be reduced by providing a mulch on the surface. A mulch is a protective covering on the soil made for the purpose of preventing loss by evaporation. It may be either artificial or natural.

An artificial mulch is formed by spreading some such material as manure, straw, leaves, sawdust, and the like, over the surface of the soil. Mulches of this kind are very effective in reducing the loss due to evaporation, but their use is practicable only for small areas of high-priced crops, such as strawberries, bush-fruits, and some few kinds of vegetables.

A natural mulch is formed by tilling the surface of the soil itself. This produces in the surface layer a loose, open structure that obstructs capillary action. Such soil mulches are very effective in reducing the loss of soil moisture by evaporation. In humid regions and in arid regions where dry-farming is practiced, from two to three inches has been found the best average depth for soil mulches. In arid regions where the soil is irrigated, a greater depth can be used. For fruits a depth

as great as ten or twelve inches is effective. For shallow-rooted crops the depth must, of course, be decreased. Spike-tooth harrows and weeders (paragraphs 223 and 225) are satisfactory implements for forming mulches. After a rain the soil mulch must be renewed, especially on a heavy soil, because the rain has reëstablished capillary communication between the lower layers of the soil and the surface. The mulch breaks up this communication.

In the so-called dry-farming that is practiced in the semi-arid regions of the West, a soil mulch is maintained throughout the whole year to conserve moisture from the previous summer and winter as well as that of the crop-producing season. In humid regions soil mulches are very effective during dry periods in summer. In the case of hoed crops, they may conserve enough moisture to keep the plants growing normally during the periods of drought. Often the conserving of water for the use of plants during such periods may be an important factor in the crop result. During a drought in southern Illinois a few years ago, the author was shown two corn fields side by side; one was suffering for the want of water and the other was thrifty and apparently well supplied with moisture. He was told that the only difference in the treatment of the fields was that one had been properly tilled to form a soil mulch and the other had not.

Soil mulches, in addition to conserving moisture, improve the physical condition of soil and, as a result, increase its water-holding capacity, thus preventing losses due to run-off and percolation. The tillage removes weed growth, which means not only a saving of the plant-food that the roots absorb, but also the moisture.

Improving soil structure to increase soil-water. — By practicing suitable tillage and by adding humus-forming matter, soil structure may be improved to increase the moisture-holding capacity. A clay soil, if worked at the proper time, is made more granular, and put into condition to retain more water.

The addition of humus-forming materials, such as farm manure, green-manure, or muck, increases the capacity of a soil, especially if it is sandy, to retain water. Humus has the power of absorbing and retaining water and when added to soil increases the water-content. Humus also reduces the size of many of the pore spaces, and, in the case of a sandy soil, results in a finer soil that is more retentive of water.

22. Irrigation. — In arid and semi-arid regions irrigation, or the artificial supplying of water to soil, is necessary for crop production. In these regions large irrigation systems that supply vast areas are installed and water rights are sold with the property, for without the water the land is practically worthless for crop production.

In humid regions irrigation is sometimes practicable, for in certain sections the rainfall is so distributed that periods of drought are likely to occur during the growing season with a consequent complete or partial loss of the crop. Vegetable-gardens, nurseries, small-fruit plantations, and greenhouses are often irrigated, but for less intensive farming the supplying of water artificially is not often profitable.

In general, four methods are in use for distributing water in irrigation. These are overhead irrigation, sub-irrigation, flooding, and furrow irrigation.

Overhead irrigation. — In humid regions overhead irrigation is used largely for watering market-garden crops, fruit crops, and in greenhouses. A system of overhead pipes is arranged in parallel lines across the area to be irrigated. These pipes, which are fitted with small holes at regular intervals, are connected with a water-supply system and water is delivered to them under pressure. The holes in the pipes are fitted with small nozzles that cause the water passing through them to break into a spray, thus preventing the packing of the soil that would result were the water to reach the ground as a stream. Fig. 17 shows an irrigated garden of the Irrigated Farms Company near Trenton, New Jersey.

Sub-irrigation. — The distributing of water through pipes or lines of tile placed underneath the surface of the ground is called sub-irrigation. Perforations in the pipe or joints between the tile allow the water to pass into the soil. It is carried to the roots by capillary attraction. This method is used in humid climates and is applicable to shallow-rooted crops. One difficulty is that the pipes are likely to become clogged by roots.

FIG. 17. — Vegetables grown under irrigation.

When a soil is sandy and is underlaid at a depth of three or four feet by a stratum of clay, conditions are favorable for the installation of a sub-irrigation system, because the soil can be saturated and the pipes emptied quickly. Since the pipes are usually empty, the roots do not enter them as they would if they held water for a greater part of the time. This system is used largely in truck-farming. In the vicinity of Sanford, Florida, it has been extensively employed for irrigating soil used for celery and other vegetable crops.

Flooding. — The method termed flooding is employed principally for watering grain fields. When a field is to be watered, the area is covered with a sheet of water from the supply-ditch which is elevated above the level of the field. This method is used chiefly in arid and semi-arid regions.

Furrow irrigation. — In furrow irrigation, the water from the supply-ditch is conducted into furrows that have been plowed across the land. The water in the furrows will soak into the soil by capillary force until the whole area has been watered. This system is especially applicable to fruits and vegetables and is largely employed in the western part of the United States, although it is found installed in a few places in the East and Southeast. In Fig. 18 is shown a section of an orange grove in California watered by furrow irrigation.

Fig. 18. — Furrow irrigation in a California citrus grove.

23. Soil drainage. — Lowering the water-level by drainage is the farmer's method of reducing the quantity of water in the soil. There are many large areas of land in the United States that are practically worthless for farming because of too much water and by the installation of proper drainage-systems many such areas could be made to produce abundant crops. On many farms there are low wet places that, if drained, could be used to increase the tillable land. Drained land is usually

very valuable for cropping purposes, as fertile soil from higher localities has generally been washed down to the low areas for a long time before draining. If the place is swampy, vegetation may have been accumulating and decaying for years, thus forming muck, an extremely valuable soil type for certain crops. There are two methods employed in land drainage, (1) the open-ditch method, and (2) the underdrainage method.

Open-ditch drainage. — When land is so level that very little grade from the beginning of the ditch to the outlet is possible, open-ditch drainage is employed to lower the water-level. Fig. 19 shows such a ditch on level land in New Jersey. Open ditches are objectionable and are not used when underdrainage can be employed. They occupy land that, if underdrained, could be tilled, they interfere with the tillage and other cropping operations of the farm, the ditch banks promote the growth of weeds, and the ditches must be cleaned out periodically, which is an expense not necessary with underdrains. However, with all these objections, open ditches are useful and can often be employed profitably where underdrainage is not practicable. Large areas of level muck land can often be effectively drained by means of open ditches that could not possibly be drained by any other method. This is the condition of the land shown in Fig. 19.

Fig. 19. — An open drainage ditch in muck soil in New Jersey.

Underdrainage. — Usually in underdrainage, short sections of burned clay tile are placed end to end in a ditch which is immediately filled with earth. Thus the land above the tile can be farmed. Before laying the tile, the bottom of the ditch is smoothed and accurately graded. The water enters the tile through the joints and, encountering a smooth channel, flows to the outlet. Tile drains operate best if the grade is one or two feet in a hundred, but they will operate satisfactorily if the grade is only three or four inches in a hundred feet, provided it is uniform. The depths of drains should be from two feet for a clay loam or other moderately heavy soil to three and one-half feet for an open soil like a sandy or gravelly loam. The penetration of roots in clay loam is less deep than in the more open soil. The distance between the drains is governed largely by the kind of soil and its wetness. For general farming, there should never be more than one hundred feet between the drains; if the soil is heavy and badly in need of drainage the distance should be much less. The outlet of the ditch usually requires protection. The tile here are often exposed and, to avoid breakage, a length of iron pipe can be used advantageously in place of the last few tile or the outlet can be protected by a wall of masonry.

24. Air in soil. — Oxygen, carbon dioxide, and nitrogen of soil air are needed in plant growth. Oxygen must be present, as seed will not sprout nor plants grow without it. A soil saturated with gravitational water does not contain oxygen, because the water has crowded out the air and occupies all the pore spaces. A plant kept even for a relatively short time in a water-logged soil will die for want of oxygen about its roots. Water standing on a field for even a few days is likely to result in the loss of the crop.

The oxygen is also needed for the oxidation of the organic matter in the formation of humus. If this did not take place in the soil, there would soon be more undecayed organic matter than live plants on the earth. A sod turned under in a soil

that is in need of surface drainage will not decay for several years, due to the absence of air, but sod turned under in a well-aërated soil will decay in a few months.

The carbon dioxide of the soil air gets into the water of the soil, where it aids in making plant-food more readily soluble. Water containing carbon dioxide is a much better solvent of plant-food than is pure water.

The nitrogen of the soil air is needed in the life process of the bacteria that live in the soil and on the roots of the legumes — clover, peas, and the like. Some of these bacteria take free nitrogen from the air and convert it into soluble forms that are available as plant-food. Free nitrogen cannot be taken up as food by roots until it has been combined with certain elements to form a soluble compound.

All the tillage practices aërate the soil. Thus one of the benefits of tillage is to increase the quantity of air.

25. Bacteria in soil. — The minute organisms known as bacteria form a very essential contituent of soil. In fact if there were no bacteria in soil, there would be no plant growth. A very important effect of bacteria in soil is the decay of organic matter to form humus. Bacteria also have an effect on the amount of nitrogen that is available in soils. Nitrogen of organic matter is made available by the process of nitrification. In this process the work of three forms of bacteria is necessary; the first form changes the organic nitrogenous compounds into ammonia, the second, changes the ammonia into compounds called nitrites, and the third, changes the nitrites into nitrates. These compounds are available as plant-food and in this form the nitrogen is useful to most crops.

What is termed denitrification sometimes takes place in soils. This is an undesirable process, the reverse of nitrification, and is the work of bacteria that change the nitrates into nitrites. From nitrites other bacteria are likely to change the compounds into ammonia and finally into free nitrogen, which means a loss of nitrogen that had been available as plant-food. It has

been found, however, that, if the soil is kept in good physical condition and is well drained, denitrification probably will not occur. This, then, is another reason for handling the soil in a manner to keep it in good tilth.

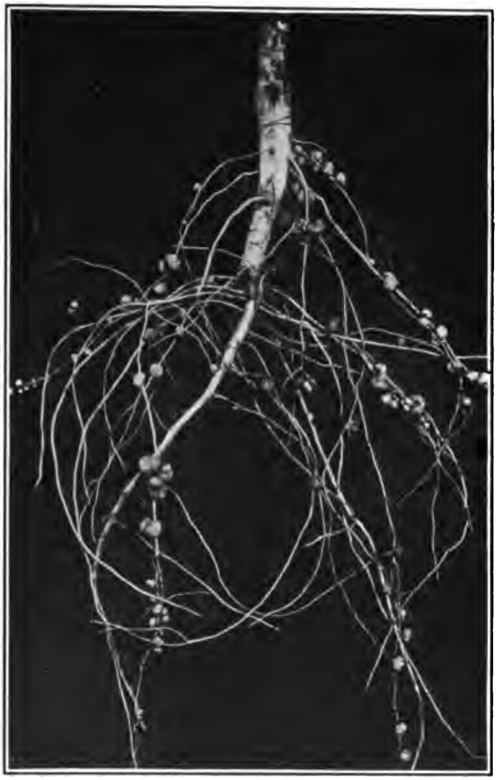

Fig. 20. — Cowpea root showing tubercles.

As stated in paragraph 24, bacteria that live on the roots of legumes are able to take nitrogen from the air and convert it into a soluble form. On the roots of legumes that are growing under favorable conditions, there are tubercules, or knots (Fig. 20). In these live the bacteria that do the work of changing the nitrogen into a soluble form. The bacteria receive food from the plant on which they are found and in turn benefit their hosts by making the nitrogen soluble. If the legumes are properly inoculated with bacteria, some of the nitrogen may remain for crops that grow later in the soil. Thus the land on which clovers or other legumes are growing is richer in nitrogen than before the crop was planted. This accounts for the good crops that usually follow legumes on a field. Legumes are often planted and, instead of being

harvested, are plowed underneath the soil to enrich it. Such a crop is known as a green-manure. (See paragraph 27.)

Each kind of legume seems to have its own particular kind of bacteria on the roots of the plants. If the right sort of bacteria is not present in the soil, the crop will not receive the benefit of the added available nitrogen, for no bacteria will be found on the roots of the plants to change the free nitrogen. The bacteria multiply so rapidly, however, that a field can easily be inoculated with the proper species of bacteria. This is accomplished, provided tubercules are found on the plants, by spreading, on the land to be inoculated, soil from a field where the same kind of crop has been growing. About five or six bushels of soil to the acre is sufficient, if it is spread thinly and harrowed well into the soil at once. The spreading should be done on a dark cloudy day or after sundown, because sunshine kills bacteria. Pure cultures of bacteria for inoculating the seed of legumes can be obtained from seedsmen and in small quantities from the United States Department of Agriculture. These cultures are mixed with water and spread over the seed, which is to be planted and, in this way, the bacteria are carried into the soil.

QUESTIONS

1. What is soil and of what is it composed?
2. What are the benefits of humus in the soil?
3. Distinguish between residual and cumulose soils.
4. What is a humid soil, a light soil, a loam, a silty soil?
5. Explain the three so-called forms of soil-water.
6. Tell ways in which the farmer can increase the moisture-content of his soil.
7. Of what use is a soil mulch?
8. Under what conditions is irrigation practicable in humid climates?
9. Why is air needed in a soil?
10. How does a crop of clover benefit the land?
11. Distinguish between soil texture and soil structure.

EXERCISES

1. **Soil constituents.** — Place a handful of loam in a tall bottle or a mason jar; nearly fill the vessel with water and shake for several seconds, then allow the soil to settle. What can you say of the sizes of the mineral particles of this soil?

Also, place a few grains of rich garden soil on an asbestos-covered screen and heat until the soil becomes red hot. Does an odor result? What are you burning out of the soil?

2. **Types of soil.** — Write to the Chief of the Bureau of Soils at Washington for a soil survey pamphlet of your county, if one has been issued. Study the maps and descriptions in this pamphlet. Visit, if possible, each of the soil types and collect samples and classify them according to name. Examine each of the soil types for color and texture. What kinds of crops are usually grown on each soil type? Were you choosing a farm in your county which type would you select?

3. **Water in soil.** — Place a small quantity of air-dry soil in a test tube and heat carefully over a gas or alcohol flame. Moisture will collect on the sides of the tube. This moisture was held largely in the soil as hygroscopic water.

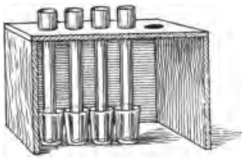

Fig. 21. — Apparatus for soil exercises with water.

Arrange four lamp chimneys as shown in Fig. 21. Using two of the chimneys, place dry clay soil in one and dry sand in the other so that the soil stands at the same height in both of them. Place empty tumblers beneath each and pour the same quantity of water into the tops. Record the time required for water to drip from each tube. What force caused the water to percolate? What form of soil-water dripped from the tubes? Compute the water in each tube after dripping has ceased. Which soil retained the more water?

Arrange the other tubes as just directed and place the bottom of each in a tumbler partly filled with water. Record the time necessary for moisture to reach the top in each kind of soil. What force caused the water to rise against gravity? What form of soil-water is in these tubes? How much water was taken into the soil in each tube? Try this experiment with long glass tubes. Explain the results.

Place a quantity of sand in a pan and gradually let water drop on the sand at one side of the pan. Eventually, all the soil in the pan becomes wet. What force carries the water?

4. **Soil mulch.** — Place sand in two chimneys and on the sand in one place a layer of fine, dry soil. Leave the other uncovered. Place

the bottoms in water and observe what happens when the moisture reaches the fine soil. Of what use is a soil mulch?

5. **Influence of lime on soil structure.** — Make four wooden molds one inch by one inch by four inches. Fit a layer of cheese-cloth into each allowing an inch or so to stick out from the sides. Weigh out four one hundred-gram lots of dry clay soil. To one lot add one gram of caustic lime; to a second lot, five grams; to a third lot, ten grams; add no lime to the fourth. Mix the lime and the clay. To each sample add just enough water to make the soil plastic and press the four lots of soil into the four molds. Remove each lot from the mold, being careful to retain the shape. As soon as you take them from the mold, mark a number on each brick to designate it. Put the bricks away to dry. When thoroughly dry, break them into pieces and observe the difference in the ease of breaking. What effect does the application of lime have on the structure of a clay soil?

6. **Air in soil.** — Place some soil in a tumbler and pour water on it until a small quantity stands over the surface. Notice the bubbles passing through the water. These are bubbles of air caused by the water displacing the air in the soil. Get two tin cans of the same size. Punch holes in the bottom of one and not in the other. Put soil in the cans to within an inch of the top and plant six grains of wheat in each can. Keep the soil in one can saturated with water and in the other one moist, but not too wet. The seeds will not sprout in the very wet soil. Why is this?

Saturate the soil in a tumbler in which a healthy plant is growing. Keep the soil wet. Observe results. What is the condition of the soil? What does it lack that is needed by a growing plant?

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CHAPTER IV

SOIL FERTILITY

The food elements of plants.
- Nitrogen, phosphorus, and potassium.
- Maintaining the plant-food supply.
- Removal of plant-food from the soil.
- Benefits of crop rotation.
- Feeding live-stock in relation to soil fertility.

Green-Manure

Use of green-manure crops.
Crops used for green-manure.
- Red clover, crimson clover, cowpeas, soybeans, vetches, Canada field peas, velvet beans, beggarweed, bur clover, rye, buckwheat.

Farm Manure

Importance of farm manure.
Kinds of farm manure.
- Horse, cow, hog, sheep, poultry.

Composition and character of farm manure.
- Influence of litter.
- Influence of class of animal.
- Influence of age of animal.
- Influence of kind of work done by animal.
- Influence of feed.
- Losses due to improper handling.

Methods of handling manure.
- Hauling manure direct to the field.
- Use of a concrete pit.
- Use of a covered barnyard.
- Allowing manure to accumulate in stalls.

Methods of applying manure.

THE handling of the soil in respect to its fertility we are to learn in this chapter, discussed in such subjects as the plant-food elements, rotation of crops, the saving and application of

stable manures, the growing of green-manure crops. We consider here what may be called the home practices and supplies. To supply humus is one of the great necessities in farming, as well as to add directly to the plant-food content of the soil. The element of conservation, or saving, is also very important, for we cannot make headway if we neglect or waste the materials produced on the farm. The soil and the live-stock can utilize most of the wastes and the materials not sent directly to the market or used as food for human beings and animals.

26. The food elements of plants. — In order that normal crops may be produced, all of the food elements to be taken up by the plants must be present in the soil and in an available form to be absorbed by the roots. Investigation has shown that only three of these elements in the soil, — nitrogen, phosphorus, and potassium, — are likely to be low in amount. A study of these elements, therefore, is of importance to farmers, for if any one of them becomes deficient, profitable crop production cannot possibly continue on that soil. These three elements are contained in fertilizers and barnyard manure. They are among the foods taken up by plants from the soil; consequently, whenever weeds, stubble, or crops grown for the purpose are turned underneath the furrow-slice, the food in the plants is returned to the soil.

Nitrogen, phosphorus, and potassium. — Nitrogen is usually taken up by plants in the nitrate form. Plants like rice that grow on soil covered with water can utilize ammonia. It has recently been shown, too, that some crops use nitrogenous organic matter. Phosphorus and potassium are found in soil in mineral compounds. Many of these are almost insoluble, but they change slowly into soluble compounds, thus becoming available as plant-food.

Unfortunately there is no uniformity in the terms used to express the nitrogen, phosphorus, and potassium content of soils, manures, and fertilizers. In some instances the names

of the elements are used, and in others the terms ammonia, phosphoric acid, and potash.

Ammonia is a compound made up of nitrogen and hydrogen, of which 82.3 per cent is nitrogen. To convert a number representing ammonia into terms of nitrogen, multiply by .823; and to convert a number representing nitrogen into terms of ammonia divide by .823 (or multiply by 1.215). (See paragraph 41.)

When the term phosphoric acid is used, it does not have reference to the common chemical by that name, but to a substance known as phosphoric anhydride, or phosphorus pentoxide, which contains 43.66 per cent of phosphorus. To convert a number representing phosphoric acid into terms of phosphorus multiply by .4366 and to convert a number representing phosphorus into terms of phosphoric acid divide by .4366 (or multiply by 2.29).

The term potash refers to potassium oxide, a compound that contains 83 per cent potassium. To convert a number representing potash into terms of potassium multiply by .83, and to convert a number representing potassium into terms of potash divide by .83 (or multiply by 1.024).

Formerly the names of the compounds were most often used, but the tendency of late is to use the names of the elements. This latter method is much simpler. In some states the fertilizer laws (paragraph 40) require that the phosphorus and potassium content of fertilizers be expressed in the terms of the elements; in other states they must be expressed in terms of the compounds.

Maintaining the plant-food supply. — In most virgin soils the supply of plant-food is comparatively large and crops can be grown for a number of years without returning any to the soil. As crops continue to be removed, however, the store of plant-food becomes less and less until finally the yields decrease so much that, unless some rational farming practice is adopted, the soil will wear out. Some virgin soils are

richer than others and will last longer, but even very rich soils will wear out in time unless the supply of plant-food is replenished.

The growing of legumes is one method of helping to maintain soil fertility, but, as the legumes are instrumental in adding only nitrogen to the soil, some other way must be found to supply phosphorus and potassium. To this end certain fertilizer materials containing these elements must be added to the soil. A list and descriptions of these are given on subsequent pages.

Investigation by means of chemical analyses and practical field tests can determine whether or not certain elements are lacking in a soil. The experiment stations in most states have made these tests for the important soil types and their officers are able and willing to give information about the various needs of the soils in their state. Often it will pay farmers to write to these men concerning the best practice to follow in maintaining the fertility of their farms.

Removal of plant-food from the soil. — Plant-food is removed from the soil in several ways, chiefly by cropping, by soil washing, and by leaching. A hundred-bushel crop of corn will remove from an acre approximately 148 pounds of nitrogen, 23 pounds of phosphorus, and 71 pounds of potassium. A fifty-bushel crop of wheat requires 71 pounds of nitrogen, 12 pounds of phosphorus, and 13 pounds of potassium. A four-ton crop of red clover takes 160 pounds of nitrogen, 20 pounds of phosphorus, and 120 pounds of potassium. From these figures it will be seen that cropping, with the plants sold off the farm, will soon remove much plant-food from the soil. It has also been determined that only about 2 per cent of the nitrogen, 1 per cent of the phosphorus, and $\frac{1}{4}$ per cent of the potassium in a soil is likely to be available for a crop in a season. Experiments show that in one of the rich soil types of Illinois, if hundred-bushel corn crops were removed each year, there would be nitrogen enough in the soil to last thirty-four years;

and in a certain soil in Maryland, if hundred-bushel corn crops were removed from the soil, there would be a supply of nitrogen for only nine years. Cropping of land without returning plant-food to the soil is not good farming.

The washing of the soil removes much plant-food. It is the top soil, the part richest in humus and plant-food, that is carried away. Some soils wash more readily than others; those containing a large proportion of silt and fine sand wash very badly. Soils in the Southern States wash readily, largely because washing may occur during the entire winter as well as during other seasons. Many soils in that section, also, are of a texture that causes them to wash readily. Cover-cropping and terracing will help to prevent this. In the Southern States it is possible to have a crop growing on the soil all winter, which helps to hold the soil from washing and stores fertility in the plants. These plants can be cut for forage or be turned under in the spring to supply humus and, if the crop is a legume, nitrogen is added to the soil.

Terracing to prevent washing is necessary on many farms. To be effective, the terraces should be covered with vegetation; otherwise they may be quickly washed away. Grass is usually employed as a covering. One grower in South Carolina plants strawberries on his terraces and makes the crop profitable.

Soluble foods are leached out of the soil. The loss in this way is large in some soils, especially in those of a sandy nature. One way to prevent loss by leaching is to grow a crop on the soil to use up the food before it leaches away. Cover-crops are useful for this purpose. More loss from leaching occurs in warm climates than in cold, because freezing of the ground prevents leaching. This, therefore, is another reason why the farmers of the South should use winter cover-crops.

Benefits of crop rotation. — Experience teaches that the continuous growing of the same kind of crop, such as cotton, corn, wheat, on the same land year after year results in the decrease of the soil products. Rotation of crops should be practiced.

In the northwestern part of the United States where wheat has been grown continually on certain areas for more than twenty years, these pieces are no longer profitable for wheat and some other crop must be planted at least once every two or three years. In the Central States where corn is the principal crop, farmers have been able to continue raising this grain by alternating it with some cereal crop, such as oats or wheat. However, many progressive farmers in these regions now include a legume on each piece of ground at stated intervals and find that this method pays. In the cotton states where the continual cropping of cotton has been practiced a long time, planters are beginning to realize that they can grow a larger product if they plant some other crop on the land at intervals. Crimson clover, cowpeas, soybeans, velvet beans, and corn are excellent crops to go with cotton.

Rotation makes it possible to plant crops having different length of root systems. For example, red clover, which has deep tap-roots, and grains, which have fibrous roots, may be planted in a crop rotation. Also, plants that make their chief growth at different times of the year may be planted; wheat, for example, grows principally in early summer and corn in the late summer.

Rotation of crops helps to control weeds. In grain fields weeds are usually destroyed when the ground is put into grass; a hoed crop like corn gets rid of weeds that may have been a pest in the field when it was planted to other crops.

Insect pests may be combated by changing the crop, for certain insects will migrate or starve if their favorite food is removed. For example the corn root-worm often becomes very troublesome when land is continually cropped in corn, but this pest can be practically destroyed by cropping the land in other plants for a few years.

Another advantage of rotation is that one or more legumes can be included in the rotation. Even if the plants are not plowed under for green-manure, which is often practicable,

nevertheless they add some nitrogen to the soil. In all sections of the country legumes suited to the particular soil and climatic conditions can be found and many progressive farmers are now helping to maintain the fertility of their soils by planting legumes for green-manure, for hay, for pasturage, or for seeds.

Feeding live-stock in relation to soil fertility. — A business-like method of returning to the soil the fertility taken up by crops is to feed these crops to live-stock, save the manure carefully to prevent excessive loss of plant-food, and place the manure on the soil. Only part of the plant-food and organic matter of the feed remains in the animal body; the remainder is excreted in the manure. On many live-stock farms much feed for the animals is purchased and the fertilizer elements thus brought to the farm are recovered in part in the manure. If legumes are in the rotation on live-stock farms and the feed grown together with that purchased are fed and the manure saved, it is possible to maintain the nitrogen and organic supply of the soil. In some cases the mineral elements — phosphorus and potassium — may need to be purchased, but, as these are not usually expensive in normal times, the cost of maintaining the fertility of the soil on such farms is not excessive.

GREEN-MANURE

27. Use of green-manure crops. — A green-manure crop may be defined as one planted for the purpose of plowing under. Crops plowed under help to maintain fertility and humus and also act as cover-crops, thus preventing excessive soil washing and plant-food leaching. Often the most economical way of building up a piece of poor land is to devote it entirely to green-manure for a year or more. In carrying out such a practice legumes should be used, and it will probably be well to use some fertilizer containing phosphorus and potassium in order that the foods in the soil will be balanced after nitrogen has been added by the legumes.

Legumes are the most satisfactory plants for green-manure; they make a good growth of foliage, add nitrogen to the soil, and their roots, in most varieties, reach down deep and bring up food that would not be obtained by shallow-rooted crops. The cheapest way to secure nitrogen is to plant legumes and turn the crop under. Nitrogen, if purchased in commercial fertilizers, costs from fifteen to thirty cents or more a pound; in legumes it often costs the farmer less than three cents a pound. Each section of the country has legumes that can be grown profitably as green-manure. In Fig. 22 is shown the result of the growth of corn on different plots of ground at the Rhode Island Experiment Station. The plots were different only in the green-manure crop, the kind and quantity of fertilizer used on each of the plots being the same. Notice that the smallest growth was where no green-manure crop was used, that the next largest was where rye, a grain, was planted, and that the best results were obtained where a legume was grown.

28. Crops used for green-manure. — The crops listed in the next few paragraphs are the ones chiefly used for green-manure. In addition to these, however, there are many crops of local importance that give very good satisfaction. One should always use a crop that does well in the region where it is to be grown.

Red clover. — Although red clover is more often used for hay than for green-manure, it is, nevertheless, very satisfactory for the latter purpose. It is a northern-grown crop. The seed is often sown in July or August, eight to ten pounds of seed to the acre giving a good stand. The clover may be plowed under the following spring or a crop may be mowed about the first of June, the second crop allowed to grow, and the plants plowed under in the fall or spring.

Crimson clover. — This clover is a desirable crop for the eastern part of the country from Delaware southward. It does not do well in the North. In the South the seeds are sown

FIG. 22. — Benefits of green-manuring. *a*, corn grown with a leguminous cover-crop; *b*, grown without a cover-crop; *c*, grown with a rye cover-crop.

about August or September. In the middle sections, as in Maryland, the seeding may be done in July. The plants are usually plowed under in the spring, but in some sections they are allowed to produce seed and are plowed under the next fall after planting. The usual acre-rate of seeding is from twelve to twenty pounds.

Cowpeas. — Especially in the South, cowpeas are used extensively for green-manure. The plants produce a large quantity of foliage; consequently they return much humus to the soil. The seeding may be done in the spring as soon as danger from frost is over or may be delayed until early summer. The plants will then be ready for plowing under either early or late in the fall. Usually two bushels of seed are planted to the acre, although some growers plant only one and secure a good stand.

Soybeans. — Like cowpeas, soybeans make a good growth of foliage and are very often used for green-manure. They can be grown farther north and are usually found north of Kentucky and Kansas, but they do well in the South, also. They are about equal to red clover in the quantity of nitrogen added to the soil. The seed should not be planted until all danger of frost is past, the usual time being about when corn planting is finished. From a bushel to a bushel and a half of seed are sown to the acre, the large-seeded varieties requiring the larger quantity.

Vetches. — Although there are several kinds of vetches, only the hairy vetch and the common spring vetch are much planted in America. The hairy vetch is known also as sand and as winter vetch. It is a hardy plant and is grown as a winter and a summer crop both in the North and South. The seed is sown in summer or fall when used as a winter crop and in spring when used as a summer crop. The plant has a trailing habit and it easily becomes matted on the ground. This makes it difficult to turn under. To obviate this difficulty, the seed is usually planted with rye, oats, or some other grain,

as the stems of the grain prevent much of the matting together of the vines. From twenty-five to thirty pounds of vetch and four pecks of grain is the usual seeding. Spring vetch is similar to hairy vetch in appearance and growth. It requires a cool climate, and is grown as a spring-planted crop in the North and as a fall-planted crop in the South and the Pacific Coast States. The crop is used most extensively where it can be planted in the fall and is preferred by many to hairy vetch. The usual range of planting is from September to November. The seed is often planted with oats. The rate of planting varies from forty to sixty pounds of vetch to an equal weight of oats. In the California citrus regions, common vetch is planted with barley as a winter cover-crop. The usual rate of seeding is thirty pounds of vetch and thirty pounds of barley. The seeds of common vetch are somewhat larger than those of hairy vetch, which accounts for the difference in the rate of seeding.

Canada field peas. — In Canada and the northern part of the United States, Canada field peas are much used as a green-manure crop. They are well adapted to a cool, moist climate and make the best growth in the spring and early summer. They are usually planted with oats. The rate of seeding varies in different sections from one to two bushels of peas to one to two bushels of oats. The seed should be planted as early in the spring as the ground can be prepared. Field peas are used as a fall-sown crop in California. From eighty to ninety pounds of seed are sown to the acre.

Velvet beans. — Especially in the citrus growing sections of Florida and also to some extent farther north, velvet beans are planted for green-manure. They make a dense growth of foliage and in a grove care must be taken that the vines do not get into the trees, for they may entwine among the branches to such an extent as to become a nuisance. A few rows of corn are often planted to provide stems on which the plants can climb. In Florida the seed is sown any time from the

middle of April to the last of May. The usual method of planting is in rows four feet apart and two feet apart in the row. A space of eight feet is left unplanted along the tree-row on account of the climbing habit of the vines. A peck of seed will plant an acre. In the light soils of Florida practice shows that the vines should be dry and partly rotted before they are plowed under. If they are plowed under when green, an acid condition of the soil unfavorable to the trees may result. October is the usual time for turning the soil. In the northern part of Florida early frosts will kill the vines and they will be dead when it is time to plow them under. In the southern and central parts the vines should be cut with a mowing machine early in the fall in order that they will be dead when the land is plowed. In sections farther north the beans are often planted with corn at the second working of the field. Their use in these sections is increasing.

Beggarweed. — In Florida beggarweed is used for green-manuring in citrus groves. It is a strong-growing plant that does well in all parts of the state. When once planted it will reseed itself, if it is not cut too early in the summer. About eight pounds of seed to the acre are sown between the tree rows about May 15. The plants should be cut when they come into bloom and left on the ground to enrich the soil. The stubble left will shoot out and produce another crop. The second crop is allowed to make seed.

Bur clover. — "Bur clover alone is commonly used as a green-manure crop in the orchards of California and is often so handled that good volunteer crops are obtained year after year.

"In the South, undoubtedly the greatest value of bur clover is due to the fact that it is the cheapest and most easily handled legume that can be used as a combination cover and green-manure crop. Even where it makes a small growth of only a few inches in height, this is sufficient to prevent to a large degree the washing of the land in winter and when plowed

under to add sufficient humus and nitrogen to improve materially the following cotton crop. It is the most economical legume to use for this purpose, as when once a stand has been secured and rows of the plants are left to seed it will volunteer from year to year. The same method can be used with corn or any other intertilled summer crop. There is some difficulty in seeding bur clover in standing cotton, as in the harrowing of the bur clover seed some of the ripe cotton is pulled out of the bolls. On this account the harrowing should be done just after the pickers have been through the field, to avoid as far as possible any injury to the opened bolls." — From Farmers' Bulletin 693.

Rye and buckwheat. — Crops other than legumes are sometimes grown for green-manure. Rye is much used. It adds no nitrogen, but it will grow on very poor soil, often on one too poor to support a legume and as it makes a good growth of stem it adds much humus-forming material to the soil.

Buckwheat, in regions where it does well, is a good crop to subdue new land. Its roots seem to break up the soil better than those of most other crops. Usually the plants are allowed to mature and are harvested, but often they are plowed under as green-manure. Buckwheat is used in many sections as a green-manure crop in orchards.

FARM MANURE

29. Importance of farm manure. — The term farm manure is used in this book to designate the solid and liquid voidings of animals, together with the litter with which these voidings are mixed. Barnyard manure, stable manure, animal manure, and stall manure are other terms often used to designate this product. Farm manure is the most important manurial resource of the farm; it contains fertility that has been drawn from the soil and must be returned to it, if profitable crop production is to be maintained. It not only benefits the soil by returning nitrogen, phosphorus, and potassium, but it ren-

ders the stored-up plant-food of the soil more readily available and adds humus and bacteria to the land. Beneficial effects of farm manure are shown in Fig. 23, which is a picture of experimental plots at the Ohio Agricultural Experiment Station. The plot at the right had an application of two and one-half

FIG. 23. — Beneficial effect of barnyard manure.. *a*, no barnyard manure applied; *b*, barnyard manure applied at the rate of 2½ tons to the acre.

tons of manure to the acre and the one at the left had no manure. Notice the difference in the growth of the corn in the two plots.

30. Kinds of farm manure. — Manure from horses, cattle, sheep, swine, and poultry are the chief kinds produced on the farm. As a rule, however, the bulk of the manure that is returned to the soil is from cattle and horses. This is because it is somewhat easier to find ways of storing these voidings than those of the other classes of farm animals and also because horses and cattle consume most of the grain and roughage of the average farm.

Horse manure is uniform in character; the dung is dry and contains a large proportion of crude fiber. The manure ferments easily, which means excessive loss of nitrogen. Horse manure also loses much fertility by reason of firefanging, a

process that causes the manure to turn white whenever a pile is left exposed for a time. Firefanging is caused by fungi and the manure so affected is of little value. The liquid portion of horse manure is rich in nitrogenous compounds, but soon after it is voided bacteria start to work on these compounds and set ammonia, a gas, free. As ammonia contains nitrogen, the fermentation means a loss of this product. Much of the fertility of horse manure can be saved by mixing the manure with that of cattle in the storage place. On account of its dry condition horse manure is known as a hot manure.

Cow manure is about equal in fertilizing value to horse manure, but it contains less fiber, consequently, less humus-forming material. Owing to its large percentage of moisture, it is known as a cold manure. A ton of cow manure contains on the average about half as much dry matter as a ton of horse manure. It does not firefang and it decomposes slowly. When stored it should be protected from the weather to prevent loss of plant-food.

Hog manure, like that of cattle, is a cold manure and decomposes slowly. The comparative quantity of plant-food it contains can be learned from Table I.

Sheep manure is rich in nitrogen and potassium, is dry, and decomposes rapidly. It is very concentrated and is often sold in bags like commercial fertilizer.

Poultry manure is very concentrated and is rich in nitrogen. On account of being so concentrated it should be mixed with litter or with other kinds of manure when applied to the soil. It is very valuable for such crops as onions that require a large quantity of nitrogen.

31. Composition and character of farm manure. — Farm manure is variable in composition and character, due chiefly to the kind and quantity of litter used, the class of animals by which the manure is produced, the age and the kind of work done by the animal, the feed of the animal, and the way in which the manure is handled.

Influence of litter on manure. — The kind and quantity of litter used has much to do with the composition of the manure. For example if sawdust and shavings are the bedding material, there is less fertility than if oat straw is used and, in addition, oat straw decomposes more rapidly than shavings or sawdust, which is an advantage. Also, if manure contains a large proportion of litter, obviously it is less valuable than if it contains a smaller quantity.

TABLE I

THE COMPOSITION OF FRESH MANURE

Excrement		Percentage of			
		Water	Nitrogen	Phosphoric Acid	Potash
Horse	Solid 80 per cent	75	0.55	0.30	0.40
	Liquid 20 per cent	90	1.35	Trace	1.25
	Whole manure	78	0.70	0.25	0.55
Cow	Solid 70 per cent	85	0.40	0.20	0.10
	Liquid 30 per cent	92	1.00	Trace	1.35
	Whole manure	86	0.60	0.15	0.45
Sheep	Solid 67 per cent	60	0.75	0.50	0.45
	Liquid 33 per cent	85	1.35	0.05	2.10
	Whole manure	68	0.95	0.35	1.00
Swine	Solid 60 per cent	80	0.55	0.05	0.40
	Liquid 40 per cent	97	0.40	0.10	0.45
	Whole manure	87	0.50	0.35	0.40

Van Slyke, L. L. Fertilizers and Crops. New York. 1912.

Influence of class of animal on manure. — The composition of the manure from the different classes of animals is different. Thorne has found that as an average of several analyses made by the experiment stations in Ohio, Connecticut, and New York, horse manure with straw contains .57 per cent nitrogen, .12 per cent phosphorus, and .54 per cent potassium, and cow manure with straw contains .46 per cent nitrogen, .13 per cent

phosphorus, and .36 per cent potassium. Table I shows the difference in the composition of manure from the several classes of farm animals. It must be remembered in studying the table that the percentages are for fresh manure and that too often in the ordinary handling of manure not all the fertility reaches the fields.

Influence of age of animal on manure. — A young animal, since it requires large quantities of nitrogen, phosphorus, and potassium in the building up of muscle and bone, takes more of these elements from the food than does an older animal. As a result, manure from young animals is less valuable pound for pound than that from mature animals.

Influence on manure of kind of work done by animal. — How the kind of work done by an animal influences the voidings can well be illustrated in the case of cattle. A cow giving milk takes out of her feed 24.5 per cent of the nitrogen it contains, while a fattening ox that has already built up his lean-meat tissues and frame requires only 3.9 per cent of the nitrogen of the feed.

Influence of feed on manure. — Since an animal will retain in its body only a portion of the fertility elements of its feed, it is evident that when given a rich feed it will void a rich manure. When a ration rich in protein is fed, a manure rich in nitrogen will result. This has been proved by experiments at several of the experiment stations. For example, Wheeler found that when a nitrogenous ration was fed to hens, the resulting manure analyzed: nitrogen .80 per cent; phosphorus .41 per cent; potash .27 per cent; and that when a carbonaceous ration (one poor in protein) was fed, the manure showed: nitrogen .66 per cent; phosphorus .32 per cent; potassium .21 per cent.

Losses in manure due to improper handling. — The method of handling the manure has more to do with its composition than any other factor. Loss can occur both by leaching and by fermentation. Leaching, which means the dissolving out

of the readily soluble plant-foods, will always occur in the case of the urine and also in the case of the solid parts when the manure is exposed to rain or snow. This loss can be lessened by storing the manure in a concrete pit or a yard that has a water-tight bottom or by spreading the manure on the field where it is to be used soon after it is voided. By this latter method the plant-food will leach out, but it will enter the soil where it can be used by the plants.

Fermentation, or the decomposing of the manure, takes place rapidly. The manure as it leaves the animal is teeming with bacteria from the digestive system and these cause it to decompose rapidly. Two classes of bacteria are at work — one known as aërobic, which require oxygen for their development and the other known as anaërobic, which work where air is either lacking or present only in small quantities. When manure is fresh it is likely to be rather loose and, if it dries, it soon becomes aërated. Under such a condition the aërobic bacteria start to work, changes are rapid, and much heat occurs. This fermentation is undesirable, as it destroys the organic matter and liberates the nitrogen. The action of these bacteria can be lessened by compacting the manure and by wetting the pile to exclude the air. The losses from aërobic fermentation are greater in horse, sheep, and poultry manures — the hot manures — than they are in cattle and swine manures.

Anaërobic bacteria work where most of the air is excluded from the pile. The changes caused in the manure are unfavorable to the loss of nitrogen and the manure rots without much loss of plant-food. This kind of rotted manure is very valuable, as it contains readily available plant-food. When a vegetable-grower places manure and soil in layers in a pile and packs and wets the pile, he makes conditions favorable for anaërobic bacteria to work. This way of handling manure is known as composting it and the pile, as a compost pile. The manure rots, but still contains much readily available plant-food.

Schutt, in a Canadian Department of Agriculture bulletin, has reported a very instructive experiment to show the effect of improper handling of manure. A quantity of mixed horse and cow manure was divided into two lots. One lot was exposed to the weather, the other was protected in a bin under a shed. The percentage of loss in both was determined at the end of six months and also at the end of a year. The percentages of loss of organic matter, nitrogen, phosphoric acid, and potash are shown in Table II. The figures are indeed significant and teach a valuable lesson. The results of a similar experiment are given in Fig. 24.

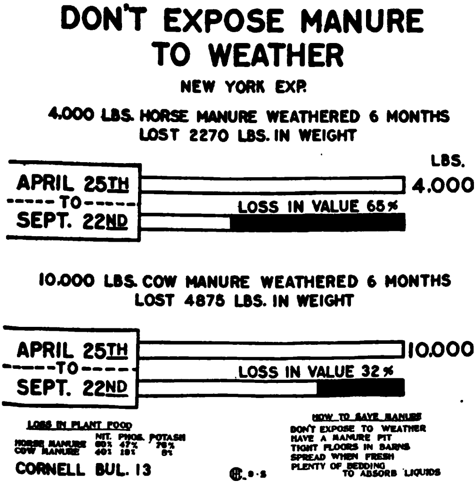

Fig. 24. — A lantern slide that tells a story of waste on American farms.

TABLE II[1]

Comparison of Protected and Exposed Manure. Percentages of Loss

	Six Months' Period		Twelve Months' Period	
	Exposed Manure	Protected Manure	Exposed Manure	Protected Manure
Loss of organic matter	65	58	69	60
Loss of nitrogen	30	19	40	23
Loss of phosphoric acid	12	0	16	4
Loss of potash	29	3	36	3

[1] Schutt, M. A. Barnyard Manure, Canadian Dept. of Agriculture, Central Experimental Farms. Bulletin 31.

32. Methods of handling manure. — From the foregoing statements it is plain that much of the value of manure can be lost by careless handling. In fact it has been estimated that about one-third of the value of the manure of the United States is lost annually and that this annual loss amounts to $708,466,000. Much of the loss can be prevented by the proper handling of the product. It is, of course, necessary for the farmer to adapt the method to his particular circumstances, keeping in mind the value of the manure, the ease with which

FIG. 25. — The wrong way to store manure, piling it by the roadside.

organic matter and plant-food are lost, the kind of farm he maintains, and the practicability of handling the manure in a particular way. Fig. 25 shows the wrong way to store manure.

Hauling manure direct to the field. — If the farming can be so arranged, it is advisable to haul the manure from the stable daily and spread it on the field at once. Many farmers have adopted this method successfully. They try always to have some field on which the manure can be spread, and to save spaces near roads for muddy days. In the winter in cold climates the manure may be spread on the snow or on the frozen ground without much loss of fertility. In the case of a dairy

farm, fresh manure is so very wet and heavy that it is necessary to have a tight wagon-box in which to carry it. A manure-spreader cannot spread the wet, heavy mass of material. A wagon-box lined with metal has not proved very satisfactory, because the acids of the manure soon corrode the metal and cause the box to leak.

A home-made tank-like box, illustrated in Fig. 26, has been used successfully. The sides of the box are of cypress plank 1¾ inches thick. The middle bottom piece is a 3-inch by 8-inch oak plank and the piece on each side of the oak plank is

FIG. 26. — Home-made tank wagon-box for hauling fresh manure to the fields.

cypress, 3 inches thick, tapered to 1¾ inches to fit the side pieces. The ends are of 2-inch plank and rabbeted. The box planks are beveled together to conform to this shape and are plowed for a slip tongue-and-lead joint. They are also plowed at each end to receive the rabbet of the end pieces. When put together the box is drawn tight by the band-iron and clip.

Use of a concrete pit. — Many farmers make use of a concrete pit as a place in which to store manure. Such a pit should have a concrete bottom and sides in order to prevent excessive leaching of the plant-food from the pile. The manure should be spread out over the surface of the pit and be kept moist; this

helps to prevent the loss of nitrogen by fermentation. A roof and sides should be placed over the pit and the whole screened to keep out the flies. This latter is a sanitary measure. Flies breed in manure and the numbers in a season can be greatly reduced by keeping them away from the manure.

Use of a covered barnyard. — The building of a roof over the barnyard and the storing of the manure there is an economical way of handling. The yard should, of course, have an impervious bottom to prevent loss from leaching. If the animals are allowed to exercise there, they will tramp the manure and

FIG. 27. — The wrong kind of barnyard. Plant-food and humus are wasted in such yards as this.

keep it moist, which is an advantage. Frear of the Pennsylvania Station found the loss in covered and trampled manure to be nitrogen, 5.7 per cent, phosphoric acid, 8.5 per cent, and potash, 5.5 per cent, and the loss in covered and untrampled manure to be nitrogen, 34.1 per cent, phosphoric acid, 14.2 per cent, and potash 19.8 per cent. The use of a covered barnyard without an impervious bottom is not advised. Even if the bottom is hard earth, about one-third of the fertility is lost by leaching. In Fig. 27 is shown a common type of barnyard, — a covered barnyard would be much better.

Allowing manure to accumulate in stalls. — In some sections a plan in use is to allow the manure to accumulate in the stalls,

fresh bedding being added from time to time to keep the animals clean. Experiments show that, as far as fertility and labor are concerned, this is a good way to handle manure. There is little loss of nitrogen as long as the animals remain in the stalls; the wetting of the manure and the trampling it receives help to prevent loss. When the animals are removed there is considerable loss of nitrogen, because the drying out of the material admits air which allows bacterial action to proceed vigorously. Consequently manure stored in this way should be taken to the fields as soon as the animals are removed from the stalls permanently.

33. Methods of applying manure. — Some farmers, when applying manure to the fields, place it in small heaps to be

Fig. 28. — A manure-spreader means a saving of labor and evenness of distribution of the manure.

spread later. This is not good practice. It means loss by fermentation and the soluble portions will leach out and pass into the soil just beneath the pile. In addition there is a loss of labor; the manure must be handled twice. Manure should, as a rule, be spread directly from the manure-spreader or

wagon in an even coat over the field. In this way it is evenly distributed and a more uniform crop growth can be expected. Whenever possible a manure-spreader (Fig. 28) should be used; it means a saving of labor and evenness of distribution of the manure. There are machines on the market that will spread the manure in narrow piles where the crop rows will stand. These are especially useful for crops like corn and vegetables.

QUESTIONS

1. What three plant-foods are sometimes lacking in soil?
2. How can missing plant-food be supplied?
3. What causes soil to wear out?
4. Why should rotation of crops be practiced?
5. What is meant by a green-manure crop?
6. Which legume in your region is most used for green-manure?
7. State the benefits of farm manure to the soil.
8. Why is manure from a young animal less valuable than that from an old animal?
9. What are the advantages of hauling manure direct to the field soon after it is voided?
10. What are the advantages of a concrete pit as a storage place for manure?

EXERCISES

1. **Crop rotation.** — Write to your experiment station for information concerning the best rotations for the chief crops in your section. On a plot on the school farm or on the farm of a neighbor follow one of these rotations. On a similar plot follow a one-crop system. Compare results.

2. **Green-manure.** — Visit a farm where a green crop has been plowed under. Observe the organic matter in the soil. Watch the crops that grow on this piece and compare them with crops on similar soil where green-manuring is not practiced.

3. **Farm manure.** — Ask some live-stock farmer of your community the average amount of manure made on his farm annually. Referring to Table II and considering nitrogen worth twenty cents a pound, and phosphoric acid, and potash each six cents (normal prices), find the money loss if manure is exposed for a year.

REFERENCES

Same as preceding chapter.

CHAPTER V

SOIL FERTILITY, Continued

Commercial Fertilizers

Use and misuse of fertilizers.
Nitrogenous fertilizers.
- Nitrate of soda.
- Sulfate of ammonia.
- Dried blood.
- Tankage.
- Fish-scrap.
- Hoof-and-horn meals.
- Cottonseed meal.
- Linseed meal.
- Fertilizers from the atmosphere.

Phosphatic fertilizers.
- Bone-meals.
- Phosphate rocks.
- Phosphates from iron furnaces.

Potassic fertilizers.
- Salts from German mines.
- Wood-ashes.
- American potash.

Effects of the different plant-foods on vegetation.
- Effects of nitrogen.
- Effects of phosphorus.
- Effects of potassium.

Purchasing of fertilizers.
Fertilizer laws.
Fertilizer equivalents.
Home-mixed fertilizers.
- Method of mixing the ingredients.
- Determining the quantities of ingredients required.

Lime for Soil Improvement

Uses of lime.
- Correcting soil acidity.
- Rendering plant-food available.
- Improving the physical condition of soil.
- Lime as an aid for legumes.
- Supplying calcium by lime.

Forms of lime.
Quantity of lime to apply.

In the preceding chapter we have studied the effect on the soil of stable manures and green-crops. In this chapter we are to consider the fertilizing materials purchased in the market as commercial manufactured commodities. It is not possible always to obtain sufficient home manures, and often the more concentrated materials of the market are specially needed. Lands that have been long farmed are likely to profit much by the application of commercial fertilizers. Some kinds of crops also make special response to them. The intensive vegetable-grower would hardly know how to farm without such materials; he must grow many of his crops quickly if they are to be of good quality and be ready for an early market; the readily available fertilizer aids him to secure these results. The grain-farmer, on the other hand, has a longer season in which to grow the crop, and the product may be held for the market; he may therefore use less fertilizer and let the plants get the additional support from supplies already in the soil. When very heavy yields are desired, market fertilizers may be needed. Modern farming cannot be understood without a clear understanding of the function and use of commercial fertilizers. The use of lime for soil improvement is also treated in this chapter. Lime is very important for this purpose and in many sections more of it should be applied to the soil.

COMMERCIAL FERTILIZERS

34. Use and misuse of fertilizers. — The materials containing nitrogen, phosphorus, and potassium that are used as

commercial fertilizers are derived from mines, from by-products of manufacture, from meat-packing houses, and from the artificial fixation of atmospheric nitrogen. A large quantity is used annually. The census reports show that in 1909 approximately \$112,000,000 was spent by the farmers of the United States for commercial fertilizers and this expenditure is increasing rapidly. For example, in 1889, the sum of \$28,000,000 was spent and \$55,000,000 in 1899. In 1909, about half of the commercial fertilizer purchased was used in the South

No fertilizer. Complete fertilizer.

FIG. 29. — Effect of commercial fertilizer at Rhode Island Experiment Station.

Atlantic States; about half of the remainder was sold in the Middle Atlantic and the New England States and only about 5 per cent was used by farmers west of the Mississippi. The western lands, since they have been farmed a comparatively short time, require less fertilizer than those in the East and South. Effects of commercial fertilizer in crop growth are shown in Fig. 29. Several miscellaneous crops were planted on two plots, one with no fertilizer and one with complete fertilizer. Notice the difference in plant growth.

Although commercial fertilizer has an important use in the agriculture of this country, it is possible to misuse it. It is rather expensive, except for certain special crops, and usually does not add humus to the soil. The use of fertilizer alone

will not maintain the productivity of the soil; some method must be followed of supplying organic matter together with the fertilizer. Barnyard manure and green-manure are excellent for this purpose. The fertilizer is easy to haul from the station and the labor of applying it is small.

35. Nitrogenous fertilizers. — Nitrogen is the most expensive plant-food to purchase. In normal times it costs about twenty cents a pound. During war times it, in common with other fertilizer elements, increased much in price. It is supplied from mineral, animal, and vegetable sources and also by the artificial fixation of atmospheric nitrogen.

Nitrate of soda. — The principal mineral used to supply nitrogen is a salt known as nitrate of soda, which is obtained in a crude state in the northern part of Chile. It is purified and when put on the market is about 96 to 97 per cent pure and contains from 15 to 16 per cent nitrogen. It is readily soluble and, for this reason, the nitrogen is quickly available as plant-food. Because of the solubility of the salt, the nitrogen is easily lost in drainage water; therefore, the fertilizer should usually be applied to the growing crop rather than to the soil before the crop is planted. Small and frequent applications are preferable. For example, three applications of fifty pounds to the acre, say a week apart, is better practice than one of one hundred fifty pounds. Nitrate of soda is used to force the growth of crops, especially vegetables, and is used to some extent in mixed fertilizers. A light application spread on a hay field when the plants are making their first growth in the spring has been found profitable in some instances.

Sulfate of ammonia. — Another mineral substance containing available nitrogen is sulfate of ammonia. It is a by-product of the manufacture of coal gas, is about 95 per cent pure, and contains about 20 per cent nitrogen. As it contains a larger percentage of nitrogen, it is somewhat more economical to handle than nitrate of soda. It does not, however, become available so quickly, but it is less readily lost by percolation

to lower levels in drainage water. When used in large quantities for several seasons, it has a tendency to make the soil acid; consequently it should not be used on soils that are already acid. Like nitrate of soda, it should usually be applied to the growing crop rather than to the soil before it is plowed.

Dried blood. — An important fertilizer of animal origin is dried blood, a by-product of meat-packing houses. There are two grades on the market; one is bright red in color and contains about 13 to 15 per cent of nitrogen, the other is almost black and contains about 6 to 12 per cent. Dried blood decays rapidly in the soil and the nitrogen becomes available by the process of nitrification. It should not be distributed directly with the seeds, as it has a tendency to rot them, but should be drilled into the soil before the seeds are sown.

Tankage. — The fertilizer known as tankage is, like dried blood, obtained from the meat-packing houses, and is made up of animal refuse that has no other use. Two grades are offered for sale, the concentrated, which contains about 10 to 12 per cent of nitrogen, and the crushed, which contains from 4 to 9 per cent. Tankage is somewhat slower-acting than dried blood and has a tendency to rot the seeds if applied with them.

Fish-scrap. — The refuse from fish canneries is sold for fertilizer. Although it is somewhat variable in quality, it usually contains about 8 per cent of nitrogen. It also contains about 6 per cent of phosphorus.

Hoof-and-horn meals. — The refuse meals from factories manufacturing combs and buttons from hoofs and horns are used to some extent as fertilizer. They contain about 12 per cent of nitrogen, but they have the disadvantage of decomposing very slowly in the soil. For this reason they are not good for immediate crops; they serve only to build up the nitrogen-content of a depleted soil.

Cottonseed meal. — Cottonseed meal is a vegetable product sometimes used as fertilizer, especially in the South. It con-

tains about 6.5 to 7 per cent nitrogen, 2.8 per cent phosphoric acid, and 1.8 per cent potash. Because of its value as a stock feed and its high price, it is better practice usually to feed the meal to live-stock and apply the resulting manure to the soil than to use the meal as a direct fertilizer.

Linseed meal. — A product of flaxseed, linseed meal, contains about 5 per cent nitrogen, but like cottonseed meal, it is so high in price and so valuable as stock feed that it is not often used as fertilizer.

Fertilizers from the atmosphere. — The artificial fixation of atmospheric nitrogen has been accomplished with some success. A product known by the trade name cyanamid is now on the market. It contains about 16 per cent nitrogen. The nitrogen is not readily available, but becomes so in the soil. By many it has been used with good results. In Norway a product known as calcium nitrate is made by fixing atmospheric nitrogen; but its manufacture is not conducted extensively on a commercial scale in the United States. The product contains nitrogen in an available form for plants. The electric arc is used in converting the nitrogen into the calcium nitrate.

36. Phosphatic fertilizers. — In normal times available phosphorus in commercial fertilizer costs from four to five cents a pound. The chief sources are animal bones, natural deposits of phosphate rock, and by-products from the manufacture of steel from phosphatic iron ore.

Bone-meals. — The animal bone-phosphates are raw bone-meal and steamed bone-meal. Raw bone-meal consists of untreated bones ground to a powder. Steamed bone-meal is made of bones after the fat has been removed by steam. The steaming makes it possible to grind the bones finer and the absence of fat causes the material to decay rapidly, both of which are advantages. Raw bone-meal contains about 9 per cent phosphorus and 4 per cent nitrogen. Steamed bone-meal contains from 12 to 14 per cent phosphorus and from 1

to 2 per cent nitrogen. The phosphorus in these meals, which is in the form of a compound known as tricalcium phosphate, is not soluble in water. However, it becomes slowly soluble in the soil; consequently the meals should be used for building up a soil rather than for immediate crops.

When bone is treated with sulfuric acid, a chemical change occurs and a part of the tricalcium phosphate is converted into monocalcium phosphate, a soluble form; a part reacts with the sulfuric acid and forms dicalcium phosphate, which is soluble in weak acids, but not in water; the remainder is unchanged. Therefore, the material after treatment contains some of all three phosphates. This fertilizer is known as acidulated bone-meal, dissolved bone, or superphosphate. It contains on the average about 12 per cent available phosphoric acid and 3 to 4 per cent insoluble phosphoric acid. Available phosphoric acid is considered as including both water-soluble and citric-acid soluble, for it has been found that phosphate soluble in a weak solution of citric acid becomes available for plants relatively soon. In addition to the phosphoric acid, the acidulated meal contains about 2 per cent nitrogen.

Phosphate rocks. — The natural deposits of phosphate rocks, or mineral phosphates, are widely distributed. The most important ones in the United States are in Florida, South Carolina, and Tennessee. This rock contains from 8 to 15 per cent phosphorus. One method of preparing the rock is to grind it very fine, in which form it is known as floats, or raw rock-phosphate. The phosphorus in the rock is the tricalcium form and is not readily available, but becomes so slowly in the soil. The fertilizer is useful, therefore, in building up soil deficient in phosphorus. When mineral phosphates are treated with sulfuric acid, monocalcium and dicalcium phosphates are formed, as in the case of treated bone. The treated product is called acid-phosphate and is the kind of phosphatic fertilizer most widely used. It contains from 14 to 16 per cent available phosphoric acid.

Phosphates from iron furnaces. — In the manufacture of steel from phosphatic iron ore, a slag results as a by-product which contains phosphorus. This material when ground makes a valuable fertilizer. It is called basic slag, also Thomas slag. It contains about 8 per cent phosphorus in the tetracalcium form, which is more readily available than the tricalcium form in untreated bone or raw rock, and the fertilizer, for this reason, is usually applied to the soil as powder without treatment with sulfuric acid. The slag contains lime also which is of value, especially if applied to acid soils. (See paragraph 43.)

37. **Potassic fertilizers.** — The chief potassic fertilizers are salts taken from mines in Germany, wood-ashes, and certain American products. The potash mines in Germany are located at Stassfurt and the industry is an extensive one. During the war with Germany these fertilizers are not available and a relatively small quantity of potash can be procured.

Salts from German mines. — The chief fertilizers from the mines in Germany are a crude salt known as kainit and two refined salts, muriate of potash and sulfate of potash. Kainit is about 12 per cent potash; both of the refined salts contain about 50 per cent potash. All of these fertilizers are soluble in water and are used without treatment.

Wood-ashes. — If they can be secured unleached, wood-ashes are valuable for the potash and phosphorus they contain. Formerly they were more plentiful than at present. Unleached ashes contain about 5 per cent of potassium and 5 per cent of phosphorus.

American potash. — With no potash available from Germany, it became necessary to develop the potash resources of this country. As a result of investigations by the Government and the fertilizer companies, several sources have been developed and much of the product placed on the market. Among the materials used are ground kelp, charred kelp, Great Salt Lake potash, and Searles Lake potash, which furnish the plant-food

in the muriate form; alunite, which furnishes it in the sulfate form; and Nebraska potash, beet-root molasses potash, manure ash, cement dust, and blast furnace dust, which contain the potash as a mixture of carbonate and sulfate. Most of the product is in an available form and in the various materials ranges from about 6 to 45 per cent pure.

38. Effects of the different plant-foods on vegetation. — The effects of foods on the resulting vegetation has been exhaustively studied by scientists and some very significant facts have been established. Some of the most important of these are given in the ensuing paragraphs.

Effects of nitrogen. — Vegetative growth of that part of the plant above ground is encouraged by nitrogen. It also imparts a deep green to the leaves. Absence of this color often indicates a lack of nitrogen. In the cereals nitrogen has the tendency to increase the plumpness of grains. With all plants nitrogen is a regulator that governs to a certain extent the utilization of phosphorus and potassium. It also produces succulence in crops. This is especially desired in many vegetables, and, therefore, growers supply the soil plentifully with nitrogen, especially for such crops as lettuce, radishes, and cabbage. In the case of many general farm crops, however, an excessive use should be discouraged. In this connection it must be remembered that nitrogen is the most expensive plant-food and that, unless the crop actually requires it, an excess is an extravagance. Moreover, too much nitrogen has some unfavorable effects on crops. It delays maturity by encouraging growth; it weakens the stalks of cereals and hay crops and causes the plants to lodge, or bend over; it may lower the quality of certain grains and fruits, as is the case with barley and peaches; and it may decrease the resistance of plants to disease. However, nitrogen should be used when needed.

Effects of phosphorus. — Phosphorus hastens the maturity of plants, increases root development, decreases the ratio of straw to grain by hastening the filling out of the latter and pro-

moting maturity of the plant, strengthens the straw, thereby decreasing the tendency to lodge, improves the quality of the seeds and fruit, and increases the resistance to disease. An excess does not seem to have any bad effect on the crop. Phosphorus should be plentifully supplied and should balance the nitrogen supply. As the lack of it is not readily observed, as in the case with nitrogen, its absence from soils is not often known to the farmer. The experiment stations, especially those that have made chemical analyses of the soil types in their states, usually give reliable information about the need of phosphorus in soils of any community.

Effects of potassium. — It has been found that a sufficient supply of potassium gives plump, heavy kernels and imparts vigor to the plants; also, it delays maturity and increases the resistance of the plants to disease. In general it seems to have a balancing effect on nitrogen and phosphorus. Excessive quantities in soil have no bad effects. Experiment stations can give information as to whether it is likely to be lacking in any particular soil type of the state.

39. Purchasing of fertilizers. — Commercial fertilizers can be purchased either mixed or unmixed. The mixed goods are put together at factories and are given a name, or brand. These brands usually contain two of the fertilizer elements and often three. The fertilizers are made up of the ingredients previously described, the quantity of each ingredient used being determined by the percentage of nitrogen, phosphorus, and potassium desired in the fertilizer. The trade in mixed fertilizers amounts to millions of dollars annually. Although farmers can procure the ingredients and mix their own fertilizer, usually for less money, the ease with which mixed goods are secured and the attitude of fertilizer dealers against this home-mixing will cause the mixed product to be most widely used.

40. Fertilizer laws. — Laws for controlling the sale of fertilizers are in force in most states. The need of these laws is obvious, when one considers the many opportunities for fraud

as to the availability of the materials used and the percentages of plant-foods contained. The laws of the several states differ in some respects, but in general the manufacturers are required to pay a state tax for each brand and to print on the bags containing the mixture (1) the quantity of fertilizer in the bags, (2) the name, brand, or trade mark, (3) the name and address of the manufacturer, (4) the guaranteed chemical composition of the fertilizer.

The quantities of plant-food ingredients in a fertilizer are expressed in percentages and are figured on a ton basis of 2000 pounds. Thus if a fertilizer is said to contain 3 per cent of nitrogen, 6 per cent of phosphoric acid, and 10 per cent of potash, the quantities in pounds of the ingredients are:

Nitrogen	2000 (ton basis) × .03 = 60
Phosphoric acid	2000 (ton basis) × .06 = 120
Potash	2000 (ton basis) × .10 = 200

The composition of fertilizers is often designated by giving the percentages only, the names of the ingredients being omitted. Thus the fertilizer just considered is usually spoken of as a 3–6–10 fertilizer. As a rule the percentage of nitrogen is given first, that of the phosphoric acid second, and that of potash last, but in some parts of the country the order of the first two is reversed, making the above a 6–3–10 fertilizer.

Laws in the different states vary as to what shall be guaranteed by an analysis. Some states require a statement as to the percentage of both nitrogen and ammonia, others require that the percentage of nitrogen only shall be given. Some require the percentage of the soluble, reverted, and total phosphoric acid; others only that of the soluble and the reverted. In the case of potash some states require only the percentage of soluble; others, that the total be given. The best kind of a guarantee is one that gives not only the percentage of the ingredients, but also their availability. Some states have this requirement. Formerly it was the custom among ferti-

lizer manufacturers to complicate the statements of the analyses more than at present. Such complicated statements are very misleading and confusing.

Most states provide for the analysis of the different brands licensed for sale in the state. Officers collect samples from stock in the hands of the dealers and farmers and if these samples are found on analysis to contain less than the percentages of the plant-foods guaranteed, the manufacturers are subject to arrest. Also, the results are published, which not only helps to prevent fraud, but protects the honest manufacturer.

41. Fertilizer equivalents. — In interpreting the analysis of fertilizers, Table III will be helpful.

TABLE III

FERTILIZER EQUIVALENTS

To Convert Guarantee of	Into Terms of	Multiply by
Ammonia	Nitrogen	.823
Nitrogen	Ammonia	1.215
Nitrate of soda	Nitrogen	.165
Nitrogen	Nitrate of soda	6.064
Phosphoric acid	Phosphorus	.436
Phosphorus	Phosphoric acid	2.290
Phosphoric acid	Bone phosphate	2.183
Bone phosphate	Phosphoric acid	.458
Potash	Potassium	.83
Potassium	Potash	1.024
Sulfate of potash	Potash	.541
Potash	Sulfate of potash	1.850
Muriate of potash	Potash	.632
Potash	Muriate of potash	1.583

42. Home-mixed fertilizers. — In many cases, farmers buy the separate ingredients and mix their fertilizers at home. This practice is discouraged by the manufacturers who assert that factory-made goods are more finely ground than home-

mixed and, for this reason, are more uniform and in a better physical condition. The argument is fairly sound; nevertheless, experience shows that good results have been obtained from home-mixed goods. By screening and mixing the materials thoroughly, a well-mixed fertilizer of good physical condition can be made at home. Experiments have shown that, as a rule, home-mixing is cheaper than buying factory-mixed goods, provided the ingredients can be purchased in large enough quantities to warrant car-load shipments. The freight rates are so high on small-lot shipments that the home-mixing of small quantities usually does not pay. Coöperation among farmers is here an advantage; the organizations can buy in large lots and distribute small quantities to the individual members, thus taking advantage of wholesale prices and large freight shipments. When deciding whether it will pay to mix fertilizers at home, the farmer or organization should secure quotations from dealers for both mixed goods of a given analysis and the ingredients that will make this fertilizer and compare prices. Usually it is well to figure a dollar a ton as the cost of home-mixing, although quantities have been mixed for fifty cents a ton.

Method of mixing the ingredients. — The operation of mixing is not difficult. A smooth solid floor, shovels, a broom, a sand-screen, and a stamper or a maul to crush out any lumps that may be present are all the tools needed. A convenient stamper can be made by fitting a handle into the top of a wooden block about six inches by six inches by eighteen inches. Any lumpy materials should be crushed and the different ingredients should be placed in layers in a long pile. The pile is usually mixed by two shovelers working opposite each other who start at one end and turn the mass, a shovelful at a time, until the other end has been reached. To insure good mixing, the pile should be turned over at least three times. After each mixing, the scattered parts at the edges should be swept into the pile and, as soon as the mass has been well mixed, it should be

shoveled through the sand-screen and any lumps that will not pass through the wire mesh should be broken and mixed with the pile. The mixed fertilizer should be placed in bags to facilitate storing and hauling to the fields.

Determining the quantities of ingredients required. — The determination of the quantities of different ingredients necessary to make fertilizer of a given analysis is by simple arithmetic. Suppose, for example, it is desired to mix a 2–8–10 fertilizer, the nitrogen to come half from nitrate of soda and half from dried blood, the phosphoric acid from acid-phosphate, and the potash from sulfate of potash. Also, suppose the nitrate of soda contains 15 per cent nitrogen, the dried blood 6 per cent, the acid-phosphate 16 per cent phosphoric acid, the sulfate of potash 50 per cent potash. To find the number of pounds proceed as in paragraph 40.

2000 lb. (one ton) $\times$ .02 = 40 lb. nitrogen
2000 lb. (one ton) $\times$ .08 = 160 lb. phosphoric acid
2000 lb. (one ton) $\times$ .10 = 200 lb. potash

The nitrate of soda being 15 per cent nitrogen contains 15 pounds of nitrogen to the 100 pounds of nitrate of soda; therefore to have 20 pounds of nitrogen (half the quantity required), it will require as many hundredweight of nitrate of soda as 20 is times 15, or 20 divided by 15, which is $1\frac{1}{3}$. This equals $133\frac{1}{3}$ pounds, which for practical purposes may be taken as 134 pounds. As the dried blood is 6 per cent nitrogen it will contain 6 pounds to the 100; therefore, to have 20 pounds of nitrogen, it will require as many hundredweight of dried blood as 20 is times 6, or 20 divided by 6, or $3\frac{1}{3}$, which equals $333\frac{1}{3}$ pounds, or approximately 334 pounds. The acid-phosphate, as it is 16 per cent phosphoric acid, contains 16 pounds of phosphoric acid to the 100; consequently to get 160 pounds of phosphoric acid requires as many hundredweight as 160 is times 16, or 10, which equals 1000 pounds of phosphoric acid. The sulfate of potash, as it is 50 per cent potash, contains 50

pounds of potash to the 100; thus to get 200 pounds will require double the quantity, or 400 pounds of sulfate of potash. The pounds of the ingredients are as follows:

Nitrate of soda (15%)	134 lb.
Dried blood (6%)	334 lb.
Acid-phosphate (16%)	1000 lb.
Sulfate of potash (50%)	400 lb.
Total	1868 lb.

This is 132 pounds short of a ton. Any material such as sand or ashes may be used as filler to make up the ton weight. The same quantity of plant-food will, however, be placed on the soil if only the 1868 pounds of material are used.

LIME FOR SOIL IMPROVEMENT

43. Uses of lime. — Lime is a soil amendment and is useful in many ways. It corrects the acidity of soils, is of aid in rendering plant-food available, improves the physical conditions of the soil, often makes it possible to grow some varieties of legumes where they would not otherwise grow, and supplies the plant-food element, calcium.

Correcting soil acidity. — The principal reason for using lime is to correct the acidity, or sourness, of the soil. Lime is a base and like all bases reacts chemically with acids to form neutral salts. Any acid soil shows the good effects of applications of lime.

The usual test for soil acidity is made by means of blue litmus paper, a preparation that can be purchased in strips ready for use at drug stores. Blue litmus turns red when exposed to an acid; consequently when placed in an acid soil the paper becomes red. In making the test, a time should be chosen when the soil is moist enough to work into a compact ball. This does not mean that the soil should be wet enough to be muddy. Make four balls of earth, break each of them into two pieces, lay a piece of blue litmus paper on the broken

surface of a part of each one, and replace the parts of the ball. Leave the paper in contact with the soil in the first ball for five minutes, the second for ten minutes, the third for thirty minutes, and the fourth for an hour. If the papers on examination have turned red, the soil is acid and in need of lime. Differences in the color of the papers will give an idea of the extent of the acidity of the soil.

Rendering plant-food available. — Compounds of phosphorus in the soil are rendered available as plant-food by the action of lime. When soluble salts of phosphorus are applied to the soil, they react chemically and form either dicalcium phosphate or some such compound as phosphate of iron or phosphate of aluminum. In the soils in which lime is plentiful, the first-named compound is formed, and in soils lacking lime the other compounds result. The dicalcium phosphate is more readily soluble in the soil-water than the others; consequently in a soil not in need of lime, the phosphorus is more readily available than in one deficient in lime.

Lime has a somewhat similar action on potash; certain reactions take place in soils in which lime is abundant and set potassium free from compounds that remain unavailable as plant-food in a soil deficient in lime.

Nitrification is not active in sour soils, but it is so in neutral soils. Thus when the acidity is reduced by an application of lime, nitrification can take place, which means more available nitrogen in the soil.

Improving the physical condition of soil. — Clay soils especially are improved. They become more crumbly and can be made into good tilth more readily. Such soils often are hard and full of cracks, causing loss of moisture, but when they are plentifully supplied with lime, these conditions are not so likely to arise.

Lime as an aid for legumes. — Alfalfa and red clover do not make a good growth on sour soils. In fact it is usually impossible to secure a stand if the soil is very acid. Many soils that

formerly grew good crops of red clover are now not producing this valuable legume and very often an application of lime is all that is required to renew this stand. Often failures in growing alfalfa are due to the soils not being sufficiently limed. Field peas, cowpeas, soybeans, vetches, white clover, alsike clover, and bur clover will grow on soils low or even slightly deficient in lime; nevertheless they will respond favorably to an application of lime and make better growths. Florida beggarweed and velvet beans seem to prefer an acid soil and lime is not required on soils to be planted to these crops.

Supplying calcium by lime. — Calcium as a plant-food is found in sufficient quantities in most soils. However, analyses have been made of some soils in the Eastern and Southern States that show a deficiency of it. In soils of this kind, the marked response on an application of lime may be due partly to the favorable effect of the added supply of the plant-food.

44. Forms of lime. — Three forms of lime are in use by farmers for soil improvement. They are ground limestone, caustic lime, and hydrated lime. Limestone ($CaCO_3$), or carbonate of lime, is found as natural deposits in many parts of the country. For soil improvement it is ground to a powder and applied to the land without further treatment. Marl, chalk, and oyster shells contain carbonate of lime and can, if ground, be used as ground limestone. Caustic lime (CaO), also known as burnt lime and as quick-lime, is made by heating limestone until carbon dioxide (CO_2) is given off. It is called caustic lime because it decomposes organic substances. Thus it burns humus out of the soil. When moistened it unites with water and forms hydrated lime ($Ca(OH)_2$). Either caustic lime or hydrated lime when placed in soil soon reverts to the carbonate form. When one hundred pounds of pure limestone is burned, fifty-six pounds of quick-lime is formed and the fifty-six pounds of quick-lime when treated with water will make seventy-four pounds of hydrated lime. Thus, as far as correcting soil acidity is concerned, one hundred pounds

of ground limestone, fifty-six pounds of quick-lime, and seventy-four pounds of hydrated lime have the same value.

When choosing lime for use on soil, the farmer must keep in mind the fact that caustic lime burns out the soil humus. To keep up the supply of humus in soil is one of the most important factors in maintaining soil fertility and, except in the case of muck or peat soils, farmers cannot often afford to lose this valuable product. The results of long-continued field tests at several experiment stations show that ground limestone gives the best results. At the Pennsylvania Station, when caustic lime was used, less yields were secured and larger quantities of organic matter were destroyed than when ground limestone was used. And a very significant fact about the results at this station is that for every ton of caustic lime applied to the soil, the equivalent of four and one-half tons of farm manure was destroyed. The nitrogen in the manure would cost about $7.00 if purchased in commercial fertilizer. It should be stated in this connection that authorities do not agree about the relative values of these two kinds of lime. Some advocate the use of caustic lime, stating that it is quicker-acting, which is the case, and, further, since about half the quantity is required, the saving in freight rates of such a bulky product is a factor to be considered. It must be remembered, however, that about $7.00 of nitrogen is destroyed for each ton of caustic lime used and that this money will pay many freight bills.

Whether to use hydrated lime or some other form will depend largely on the price of the product and the amount of money that can be saved in freight charges. Less hydrated lime is used for soil improvement than the other forms.

45. Quantity of lime to apply. — The usual first application of ground limestone is four tons an acre followed by two tons every four years. In very sour soils these amounts may well be increased. There is no danger of applying too large a quantity. Caustic lime is usually applied at the rate of 1000 pounds to the acre and hydrated at the rate of 1500 pounds.

QUESTIONS

1. Why should green-manure or farm manure or both be used with commercial fertilizer?

2. How many pounds of nitrogen, phosphoric acid, and potash are present in a 3–6–4 fertilizer? How many pounds of ammonia, phosphorus, and potassium?

3. State the five benefits of lime for soil improvement.

4. What are the advantages in using ground limestone in place of caustic lime?

5. How can a soil be tested to learn whether or not it requires lime?

6. Why should soil to be planted to alfalfa or red clover be well limed?

7. For what kind of crops is commercial fertilizer especially useful?

8. What is the appearance of growing plants that are in need of nitrogen?

9. Why should dried blood and tankage be mixed with the soil in the furrow before the seeds are planted?

10. When should raw rock-phosphate be used in preference to treated phosphates?

EXERCISES

1. **Fertilizer laws.** — Write to your experiment station for copies of the fertilizer laws of your state. Study these carefully.

2. **Home-mixing of fertilizer.** — Find the quantities of material required to mix a 2–8–6 fertilizer from 15 per cent nitrate of soda, 14 per cent acid-phosphate, and 50 per cent sulfate of potash. Make up other similar problems. Get a fertilizer formula from a bag of mixed fertilizer and plan how you could mix one having the same formula.

3. **Testing soils for acidity.** — Following directions given in the chapter, test the soil in several fields near the school-house for acidity.

REFERENCES

Same as Chapter III.

CHAPTER VI

INDIAN CORN, OR MAIZE

Corn-producing localities.
Types of corn.
- Dent, flint, pop, sweet, soft, pod.

Uses of corn.
Selection of variety of corn for planting.
Selection and care of seed corn.
- Selecting ears from the field.
- Kind of stalk from which to select ears.
- Kind of seed ear to select.
- Caring for the seed ears.

Testing seed corn for germination.
- Sawdust-box tester.
- Rag-doll tester.

Soils and climate for corn.
Enriching soils for corn.
Preparation of land for corn.
Planting the seed.
- Depth of planting.
- Methods of planting.
- Rate of planting.
- Implements for planting.
- Testing the planter.

Cultivating the fields.
Harvesting the crop.
Pests of corn.
- Corn root-worms.
- Corn root-louse.
- Wire-worm.
- Cutworms.
- White-grub.
- Corn ear-worm.
- Grain-weevil.
- Migratory insects — chinch-bug, army-worm.
- Corn-smut.
- Ear-rots.

When Columbus discovered America he found Indian corn growing here. This corn was not known to European peoples before that time. The corn mentioned in the Bible was wheat or some of the other small grains. Indian corn has proved to be a very valuable accession to the crops of the world. The United States is the greatest producer. The yield in this country in 1917, a record year, was 3,191,000,000 bushels, which was about half the yield of all the grains we grew. In other words, the United States grew that year about 6,000,000,000 bushels of grain, half of which was corn.

The corn plant produces abundant feed for live-stock and a very large quantity of human food in the form of hominy, corn-meal, corn-sirup, and other products. It is the principal crop for filling silos in the regions of winter dairying. In some parts of the country much corn is eaten as human food. The South has always been a large consumer of corn in this way. Hominy will be found on the breakfast tables of most of the families every morning, and corn-bread in some form is a steady article of diet. The consumption of corn products by human beings is extending because of the Great War. Maize is extensively grown in the eastern half of the United States. The region extending from Nebraska to Ohio is specially advantageous for the crop, and it is known as the corn-belt. Maize may be considered to be the characteristic North American crop.

46. Corn-producing localities. — Indian corn is one of the most important of all crops. The world produces annually from 3½ to 4 billion bushels. Of this vast quantity North America grows about 78 per cent, Europe 15 per cent, South America 4 per cent, Africa 2 per cent, and Australia less than 1 per cent. The United States produces about 73 per cent of the corn of the world, Austria-Hungary 5½ per cent, Mexico and Argentina each about 4 per cent, Italy about 2½ per cent, Rumania about 2 per cent, and Egypt and European Russia each about 1½ per cent. In the United States about three-

fifths of the total corn crop is grown in the seven so-called corn-belt states: Iowa, Illinois, Missouri, Nebraska, Kansas, Indiana, and Ohio. Many of the best yields of corn, however, are secured in Eastern and Southern States and it is interesting to note that a number of record yields have been made by members of Boys' Corn Clubs. Corn has a wide range of growth and varieties are found for each state.

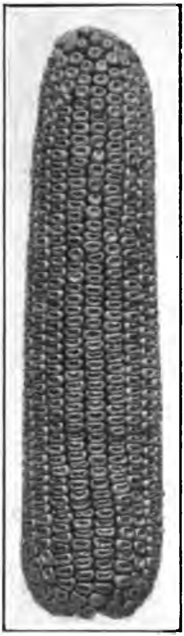

FIG. 30. — Dent corn.

47. Types of corn. — Six types, or classes, of corn are grown. These are dent, flint, pop, sweet, pod, and soft corn. The last two, however, are of little importance commercially.

Dent corn. — The type of corn known as dent is the field corn commonly grown in the United States. In a kernel of corn, there are two kinds of endosperm, hard, or horny, and soft, or white. In dent corn the hard endosperm is arranged along the sides, and the soft endosperm surrounds the germ and extends to the crown, or upper portion, of the kernel. The soft endosperm contains a larger proportion of water, which causes it to shrink more rapidly and when the kernel matures a dent is formed in the crown. In Fig. 30 the dented character of the kernels can be seen. The ears of dent corn average from eight to nine inches in length, from six and one-half to seven inches in circumference, and have from sixteen to twenty rows of kernels on an ear. The plants do not sucker freely and usually a stalk produces one ear, except in cases of the so-called prolific varieties, in which two or more ears are commonly produced on a stalk. These varieties are adapted principally to the cotton-producing states. White and yellow are the predominating colors of dent corn, although red, red and white mottled, blue, and purple ears are found. The growing season of dent

corn varies in separate localities and with different varieties from ninety to one hundred and fifty days. Some three hundred and twenty-five varieties are known.

Flint corn. — In flint corn (Fig. 31) the hard endosperm extends along the sides and across the crown and surrounds the soft endosperm and the germ. No dent is formed. The grains are oval in shape and hard, smooth, and flinty in appearance. In most varieties eight rows of kernels are found, although ears with as many as sixteen rows are sometimes seen. The ears are about the same length as those of dent corn, but are much smaller in circumference. White and yellow are the predominating colors. The plants are somewhat smaller than those of dent corn and usually produce two ears. The growing season is short and for this reason it is the type usually grown in northern regions and in high altitudes of middle and southern sections. Canada, New England, New York, and Pennsylvania are the principal flint corn areas. Some seventy varieties are under cultivation.

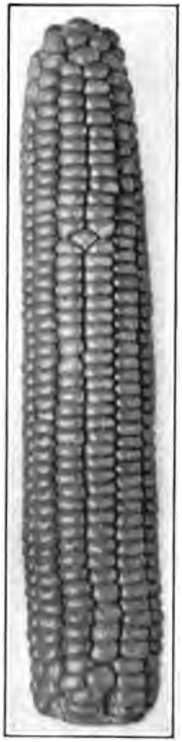

FIG. 31. — Flint corn.

Pop-corn. — The endosperm of pop-corn is nearly all of the hard, or horny, kind, although in some varieties a thin layer of soft endosperm is found around the germ. The endosperm contains considerable water and when heat is applied this water changes to steam which expands the kernel and causes it to burst into the familiar white, fluffy mass of popped corn. Two classes are grown, — rice and pearl. In rice pop-corn (Fig. 32) the crown of the kernel is in a sharp point. In pearl varieties the crown is rounded. The plants of pop-corn are much smaller than those of dent and flint corn and several

ears are produced on a stalk. Pop-corn can be grown in any region where flint or dent corn does well, but in the United States the growing of this type of corn commercially is confined largely to two counties — Sac County, Iowa and Loup County, Nebraska.

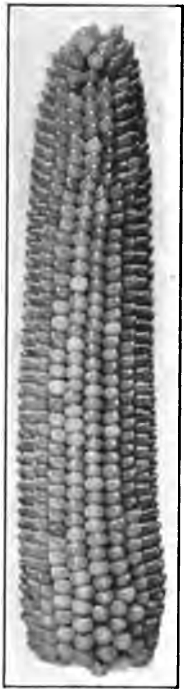

FIG. 32. — White rice pop-corn.

Sweet corn. — The carbohydrates in sweet corn are largely in the form of sugar instead of the starch of the other types, and this accounts for the sweet taste. The grains when mature are wrinkled, as shown in Fig. 33, and the endosperm when dry is horny and glassy. The ears vary considerably in size in different varieties; some are small and have eight rows of kernels like the flint corn, others are nearly as large as good-sized ears of dent corn. In some varieties the kernels are irregularly placed on the ear. The stalks vary in height from two to ten feet and the plants have the tendency to sucker freely. Usually two or three ears grow on a stalk. Sweet corn is used largely for culinary purposes; much of the product is canned. The growing season varies with different varieties and in different sections from fifty to one hundred days.

FIG. 33. — Sweet corn.

Soft corn. — The whole endosperm in soft corn is soft starch; the kernel can easily be dented with the thumb nail. The kernels are large, often measuring three-fourths inch in width.

The ears have somewhat the appearance of flint corn, except for the size of the kernel. Corn of this type is grown more largely in South America, Central America, and Mexico than in the United States and Canada. The plants are usually tall-growing and, with the exception of a few varieties, require a long season for maturity.

Pod corn. — Each kernel in pod corn is inclosed in a husk. Corn of this type is of no commercial importance and is grown as a curiosity.

48. Uses of corn. — The principal use of corn is for stock feed. The grain itself, either whole or ground, is fed to all kinds of live-stock; the stalks are used as fodder, and the whole plant, stalk and ears, is the best material available for silage. Many by-products from the manufactured products of corn are important stock foods. Among the manufactured products from corn are hominy, cerealine, breakfast foods, corn-starch, corn-sirup, corn-sugar, alcohol, paper, corn-oil, and corn-rubber. The use of sweet corn, pop-corn, and corn-meal for human foods is too well known to require further comment.

49. Selection of variety of corn for planting. — One of the important factors in profitable corn culture is the selection of the right variety for planting. Each corn-growing region has varieties best adapted to its particular climatic and soil condition. If matured ears are desired, corn is a crop that requires perfect acclimation in order to yield profitable returns. The farmer should, therefore, plant only those varieties that do well in his locality and should use seed that has been grown in his vicinity. New varieties can be acclimated, but only a relatively small quantity should be planted the first year. If some of the plants mature, from these a small quantity of seed can be selected for planting the next year, and the same plan followed for the succeeding years. By taking two or three years, a variety that has become acclimated to the region can be produced.

When corn is to be used for silage, it is not necessary that it

mature ears; consequently seed from a different locality can often be used to advantage. For example, a tall-growing southern corn may be grown in northern sections; such a corn will produce abundant foliage and add materially to the quantity of silage, but it will not produce many ears. In order that the desired proportion of ears to stalks be secured, it is a good plan to mix the seed to be planted with that of some native corn that will produce ears.

50. Selection and care of seed corn. — No matter how carefully the other factors of corn-growing are provided for, a good stand of corn cannot be expected from poor seed. The average yield of corn in the United States is less than twenty-six bushels an acre, yet there are many farmers who grow ninety bushels an acre on their whole corn-growing area and record yields as high as 228 bushels (field weight) have been grown. Significant in this connection is the fact that much of the low average yield of corn is due to the lack of proper seed selection.

Selecting the ears from the field. — The best place to make the selection of seed corn is in the field. All the ears should be gathered as soon as ripe and in northern regions before any freezing has occurred. The best practice is to go through the field with a picking bag on the shoulder and gather the ears from the stalks.

Kind of stalk from which to select ears. — The plant from which a seed ear is taken should be one that produces better corn than the surrounding individuals. If plants are growing on richer ground or by themselves in a field, they may by reason of these special advantages produce better ears, but they are not likely to have any greater producing power stored in the seed than a poor ear grown under unfavorable conditions. In the Central and Southern States, where there is a tendency for stalks to grow too tall, short thick stalks producing pendent ears at or below their middle point are a good type for seed. When exceedingly early-maturing varieties are desired, seed should be taken from stalks that produce ears high enough to keep

them from touching the ground when they become pendent. In prolific varieties all the ears of a stalk are of equal value for seed. As suckers are undesirable, seed should be taken only from stalks that produced none.

Kind of seed ear to select. — The size of the ear depends somewhat on the variety and location. Smaller ears are usually chosen for northern climates and larger ones for southern climates. The ear should be nearly cylindrical in shape; one that is too tapering contains less corn than a cylindrical ear of the same size. The rows should be straight from butt to tip; crooked, irregular rows mean kernels of irregular shape and size and, as such kernels do not pass through the planter plates regularly, irregular planting results. The tips and butts should be well filled; this means a larger proportion of corn to cob.

Too much space between the kernels next to the cob is a bad feature; such a condition gives a smaller proportion of corn to cob and the kernels are likely to have weak germs. P. G. Holden, of the International Harvester Company, reports concerning two ears of the same length and circumference, but one having much more space between the kernels at the cob than the other. One ear weighed 13.45 ounces and the other 10.12 ounces; the first shelled out 35 per cent more corn than the other. The width of the furrows between the rows should not show too much space; the space reduces the quantity of corn to cob. In some varieties, however, more space is allowed than in others. Depth of grain should be carefully looked after; shallow grains mean a small shelling percentage of corn. In general, the kernels in dent varieties should be half as long as the diameter of the cob.

The kernels should be wedge-shaped; they will then fit snugly together at the cob. Tapering kernels mean space at the cob and a small shelling percentage of corn to cob. They should have strong healthy-looking germs; dark color is an indication that the germs may have been frozen, and wrinkled germs indicate immaturity. The kernels in the different parts

of the ear, except at the butts and tips, should be of nearly uniform shape and size; they will then drop regularly through the plates of the planter. The ear should be well matured; immature corn will not keep well in storage and if planted will produce weak stalks and give poor yields.

Caring for the seed ears. — As soon as gathered, the seed ears should be stored in a well-ventilated place and arranged so that

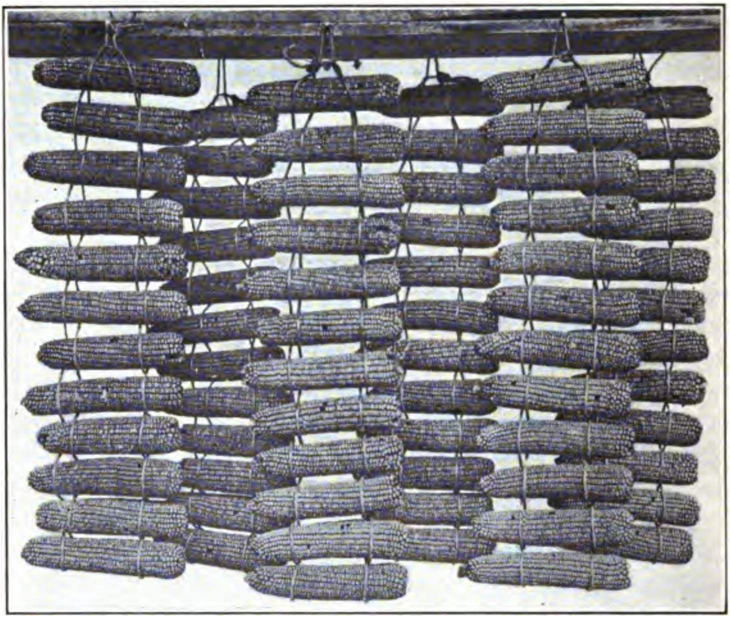

FIG. 34. — Seed corn strung with binder twine.

they will not touch each other. Stringing them with binder twine (Fig. 34), or placing them on wire racks (Fig. 35), are very satisfactory ways of arranging them for drying. The wire racks are made by cutting electrically-welded lawn fencing into strips and bending the wires on which the ears are to be placed. When the corn is as dry as old corn, it should be taken from the twine or racks and stored in a cool dry place

where neither moths, rats, nor mice can injure it. An attic or upstairs room, if free from moisture, is a good place. A pound of moth-balls or naphthalene should be stored with each bushel to protect it from the grain moth. Covering the storage boxes or crates with fly screening or woven wire of a fine mesh will protect the corn from mice and rats. If the grain-weevil is prevalent, fumigate with carbon disulfide as directed in paragraph 58.

Fig. 35. — Seed corn on racks made from wire fencing.

51. Testing seed corn for germination. — That it pays to test seed corn for germination has been proved repeatedly in all parts of the country. It was found at the Iowa Experiment Station, for example, in carefully conducted two-year tests, that the testing increased the acre-profits 93.6 per cent the first year, 85.7 per cent the second year, or an increase of 19.6 bushels and 10.1 bushels. In these experiments the cost of testing enough seed to plant an acre varied from 14.4 cents to 57.6 cents. Both home-made and manufactured testers were used and some equally good results were secured from both.

Sawdust-box tester. — One of the most used home-made

testers is the sawdust-box tester. To make and use one of these the following directions should be observed: Secure a box 3 or 4 inches deep and about 30 inches square. Place in a burlap bag enough sawdust to half fill the box and soak it bag and all in water for several hours. When moist spread it in a layer in the box and press it to a smooth even surface. Rule off a piece of muslin about the size of the box into squares about 2½ inches each way and number these squares 1, 2, 3,

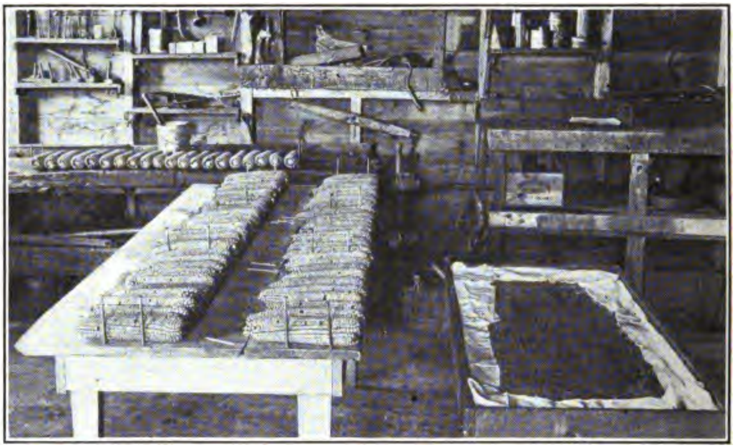

Fig. 36. — Seed corn tested in the sawdust-box tester.

and so on. Place the cloth in the box and tack it to the edges and corners. Place the ears to be tested side by side on a table or shelf and number them in order 1, 2, 3, and so on. Fig. 36 shows the ears arranged on a table as here described. With a sharp-pointed instrument remove six kernels from each ear and place them in the square in the box that accords with the number of the ear. When removing the kernels take one from near the tip, one from near the middle, and one from near the butt, turn the ear over and remove six more in the same manner. When the kernels have been placed in the squares lay a piece of muslin over them and sprinkle water on the cloth; above

this place another layer of cloth somewhat larger than the box and fill in about 2 inches of moist sawdust above this, press it down firmly, and fold the edges of the cloth over the sawdust,

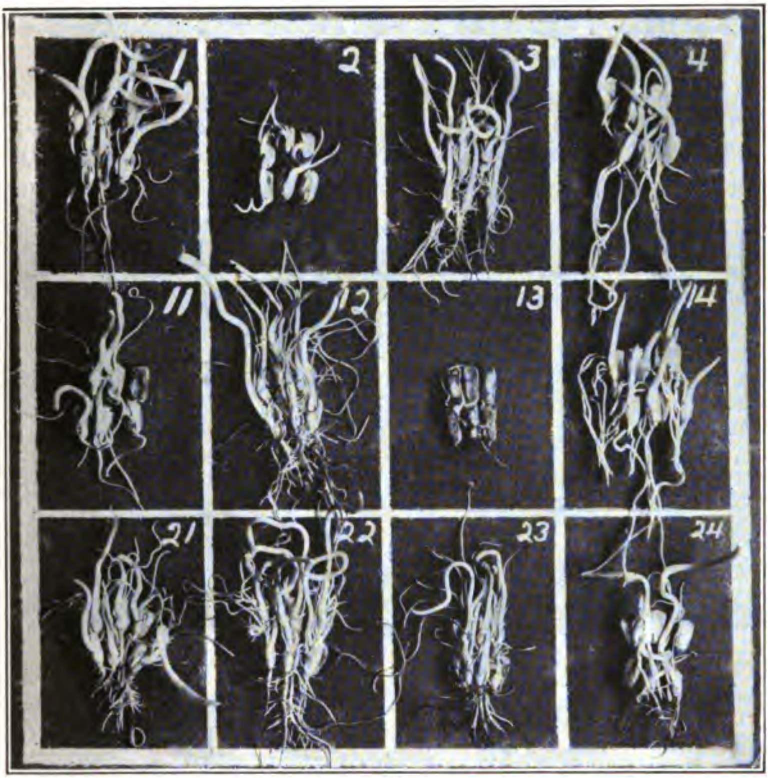

Fig. 37. — Kernels of seed corn sprouted in the sawdust-box tester.

as shown in Fig. 36. Keep this tester in a warm room and the kernels should germinate in about six days. At the end of the time remove the upper cloth, being careful to avoid misplacing the kernels in the squares. Examine the kernels and discard as seed all ears which show one or more dead or decidedly

weak kernels. Figure 37 shows kernels tested in this way. Which ones would you discard?

Rag-doll tester. — Another home-made tester that has been used with very good results is known as the rag-doll tester. One of these is shown in Fig. 38. The illustration is furnished by the courtesy of the Iowa Agricultural Experiment Station and the following description and comments are from its Bulletin 135.

"One of the cheapest as well as the most convenient and accurate methods which can be employed in testing seed corn

FIG. 38. — The rag-doll seed corn tester.

is that known as the rag-doll method. In preparing to make this test, secure sheeting of a good quality and tear into strips from 8 to 10 inches wide and 3 to 5 feet long. Where these are to be used very much it is well to hem the edges as otherwise the ravelings sometimes disarrange the kernels in unrolling. Each cloth should then be marked with a heavy pencil, first, lengthwise in the middle and then crosswise, as shown in the accompanying illustration, making squares about 3 inches wide. Number the squares as shown in the illustration also.

" Moisten one of these cloths and lay it out on a board of convenient size in front of the ears which are to be tested. Remove six kernels from ear No. 1 and place in the square No. 1 in the upper left hand corner of the cloth. Take six kernels from ear No. 2 and place in square No. 2 in the upper right hand corner, ear No. 3 in the next square on the left hand side, and ear No. 4 in a corresponding position on the right side. When the cloth has been filled begin at the upper end with ears Nos. 1 and 2, etc., and roll the cloth up. Since the cloth is moistened the kernels will not push out of place. If a small irregular shaped piece of wood or some other substance is used as a core in rolling, a more uniform germination may be secured. When the rolling of the cloth has been finished, tie a string rather loosely about the middle of the roll; or better still, use a rubber band, and number this roll No. 1. Then proceed with roll No. 2 in the same way. As many rolls may be used as are necessary to contain the corn which one has to test. From 20 to 50 ears can be tested in each roll, depending upon the length.

" After the rolls have been filled they should be placed in a bucket of water where they may remain for from 2 to 18 hours, depending upon the preference of the operator. At the end of this time pour off the water and turn the bucket upside down over the rolls — or a common dry goods box may be used for this purpose. A couple of small pieces of wood should preferably be laid under the rolls and one edge of the pail should be lifted from one half to one inch in order to give sufficient ventilation. Some have left the pail in an upright position, placing a few sticks or corn cobs in the bottom of the pail to insure proper drainage, and then packing a moist, coarse cloth over the rolls to prevent excessive drying. At the end of five days the kernels should be ready to read.

" Depending upon the arrangement of the ears, select, first, either roll No. 1 or the last roll filled. This cloth will be unrolled in front of the ears which are represented. Examine

all the kernels carefully. In all cases in which all six kernels are not strong in germination the ear should be thrown away."

52. Soils and climate for corn. — A well drained loam rich in humus is the soil best adapted for corn. Heavy clays and sandy soils are not usually good for this crop. In rotation corn does well after a grass or legume. A loamy piece that has been in clover, alfalfa, or cowpeas is an ideal medium for a planting of corn.

The crop requires a long growing season, abundant sunshine, and a plentiful supply of moisture. These conditions are found in the corn-belt states, which, together with the soil types found there, make the region well suited for corn. This must not be taken to mean, however, that many other sections are not adaptable for corn-growing.

53. Enriching soils for corn. — The use of stable manure on land to be planted to corn is profitable. When a sod piece is to be plowed for corn, the manure is often applied the spring before; it will then benefit both the hay crop and the corn that follows. Another practice is to apply the manure in the fall after the hay has been cut and before the sod has been plowed under. In this method the manure benefits the corn crop and to some extent the crops that follow.

Commercial fertilizer is often used with good results for corn, especially in the Eastern and Southern States. The formula to use depends on the soil, and the county agents in the several states can give good advice to those desiring information about a particular type of soil.

54. Preparation of land for corn. — The time of year land should be plowed for corn varies in different parts and with different farmers in the same section. Some plow in the fall; others plow in the spring. Some of the advantages of fall plowing are that the vegetable matter turned underneath the furrow-slice has time to decay, the freezing and thawing of the upturned land, if the farm is where the ground freezes, tends to pulverize the soil, many larvæ of insects are killed by the

freezing weather of winter, and the work is done at a time when other work on the farm is not pressing. A disadvantage is that much soluble plant-food is likely to be lost during the winter by percolation to depths below the reach of roots. This applies especially when the ground does not remain frozen during the winter. Another disadvantage is that the soil is likely to wash badly during the winter.

If plowing is done in the spring, it should be early in order to give time for the sod and manure to decay. The soil bacteria and the aëration of the soil are more active in plowed than in unplowed land; consequently the early plowing, through the increased action of these agencies, adds to the supply of available plant-food for the corn crop. Early spring plowing, if followed by harrowing to form a mulch on the soil, will conserve moisture. This is an especial advantage in a dry spring.

Following the plowing, the land must be made into a fine, easily worked seed-bed. Clods left in the field will be troublesome during the whole growing season, and should be broken up before the seed is planted. Corn planted on poorly prepared land has little chance to make a good crop.

55. Planting the seed. — Corn can be planted as soon as danger of frost is over and the ground has become sufficiently warm to insure germination. The time, of course, will vary considerably in different localities.

Depth of planting. — The depth that corn is to be planted should be governed largely by the physical condition of the soil. In most soils of good tilth, the planting should be shallow, about two inches. In a dry soil that is somewhat lumpy, deeper planting, from three to five inches, is likely to give better results.

Methods of planting. — The two general methods of planting corn are in hills and in drills. When planted in hills, from three to five kernels are placed in groups from three to four feet apart each way. The number of kernels to the hill and the distance apart varies with the condition of the soil. In a fertile soil the planting can be thicker than in poor soil.

Corn planted in drills is placed in rows, each kernel in a separate place. The distance apart of the kernels varies in different localities from eight to fifteen inches, depending on the soil conditions. The space between the rows varies, also, from three feet, six inches to five feet.

Often in the South the corn is planted on ridges, or hills of earth, with deep furrows between the ridges. This is largely because the drainage is poor and during a wet time the water will stand in the furrows and the ridge will be above the standing water. On sandy or loamy soils in the South, corn is sometimes planted in the water furrow instead of on the ridge. This plan is not advisable if the soils are at all heavy, but where soils are inclined to be dry, there is an advantage in this method on account of the more moist condition of the soil in the furrow.

Many of the experiment stations have tested the different methods of planting for their states and have published the results in bulletins. It will be well for pupils and farmers to communicate with the officers of these institutions to find out what has been done along this line.

Rate of planting. — The rate of planting varies considerably, ranging from three thousand to fifteen thousand stalks to the acre. If the hills are four or five feet apart with two stalks to the hill, as they are in some parts of the Gulf States, only about three thousand plants are grown to the acre. If they are three feet, six inches apart each way with three or four stalks to the hill, as often planted in the North, twelve thousand stalks are grown to the acre.

Implements for planting. — A large part of the corn grown in the United States is planted by means of corn-planters. For small areas a hand planter, known as a jabber, is very often used. In the corn-belt two-row planters are the chief kinds. Many of these are arranged to drop the kernels in groups and are known as check-row planters. One is shown in Fig. 39. In the South much of the corn is planted by means

of a one-row planter, the same implement often being used for planting cotton (Fig. 208). In some parts of the West and South, a lister is used for planting corn. This is an implement fitted with two shovels so placed that they throw a furrow both ways. The hoe through which the corn feeds is between these shovels and the corn is planted at the bottom of the furrow. The use of the lister is limited to loose, fertile soils. In the

FIG. 39. — A two-row corn-planter arranged with wire to drop the kernels into hills.

West the land is not plowed before the corn is planted and subsequent cultivation fills in the furrow as the corn grows.

Testing the planter. — A very important factor in the successful growing of corn is the testing of the planter to find out whether it will drop the kernels regularly. The testing should, of course, be done with some of the seed that is to be planted. Drawing the planter across a barn floor or along a stretch of road is a good way to determine how it is dropping the kernels. In case it does not drop regularly, the planter plates should

be changed or sometimes the difficulty can be overcome by filing the holes in the plates to make them larger.

56. Cultivating the fields. — Corn requires frequent and thorough cultivation, especially in the early stages of growth. The cultivating not only kills the weeds, but it aërates the soil and conserves the moisture, which corn requires in abundance for its best development. A weeder or a spike-tooth harrow with the teeth turned back should be used even before the

FIG. 40. — A corn-cultivator equipped with small shovels.

plants are above the ground. Many weeds will thus be killed and a mulch formed. If the work is done during the middle of a hot, sunshiny day, these implements can be used until the plants are six or eight inches high. In the heat of the day the plants are not easily broken. After the plants are large a corn-cultivator equipped with small shovels should be used (Figs. 40 and 204). Shallow cultivation (about two inches) is best for corn, as deep cultivation cuts off too many roots. In dry seasons the cultivation should be kept up until well into the summer to conserve all the soil-moisture possible. When

the plants become tall, a one-horse cultivator can be run between the rows.

57. Harvesting the crop. — The method of harvesting varies with the use to be made of the crop. If mature ears are desired, they are husked either from the standing stalks or from the stalks after they are cut and placed in shocks. In the corn-belt states, it is a common practice to drive through the field with a team and double-box wagon, husk the ears from the

FIG. 41. — A corn-binder with bundle elevator.

standing stalks, and throw them into the wagon. Live-stock are allowed to run in the fields after the corn is husked to eat any nubbins left and what stalks they will. Corn that is to be shocked before the husking is often cut by hand with large knives. There are on the market machines that can profitably be employed in cutting the stalks. Of these the most efficient is the corn-binder, which cuts the stalks, binds them in bundles, and either drops them on the ground or elevates them into a wagon driven by the side, as shown in Fig. 41. The bundles are placed in shocks and when the ears are dry they are husked (Fig. 42) and the bundles of stalks (corn stover) are stored for use later in the feeding of live-stock. Corn, when both ears and

FIG. 42. — Husking corn from the shock.

stover are to be fed, is usually cut when the husks are dry and about a third of the leaves are still green. This gives the best yield of both ears and stóver. Before this stage the corn is too immature and if cut too late many of the leaves will drop off; consequently the feeding value of the stover is much lessened. When only the ears are desired, the cutting may be delayed until the stalks are mature. A machine known as a husker and shredder is often employed to remove the ears from the cut stalks and to shred the fodder into small pieces. This shredded fodder is easily stored and is good feed, especially for cattle.

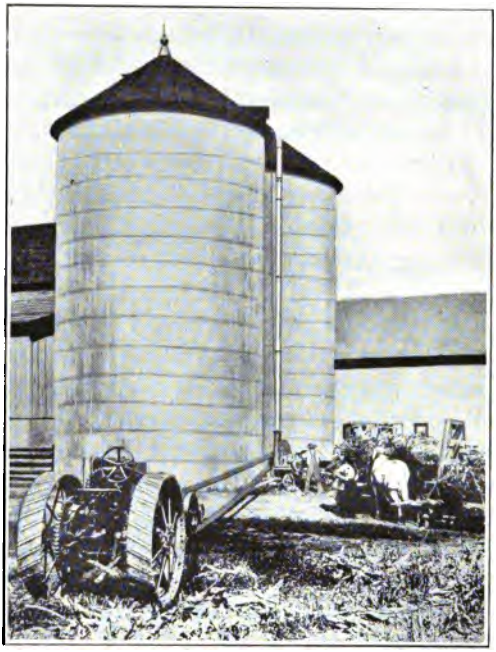

FIG. 43. — Filling the silo.

Fodder-pulling is a method employed in some parts of the South for securing forage from the corn plant. Handfuls of leaves are pulled from the standing stalks, tied together, and hung on the stripped stalks to cure. Topping of corn is another method used in the South. This consists in removing the top of the stalk above the ear and placing these in shocks to cure for fodder. In either method the ears are later removed for grain. Experiments have shown that these practices result in a loss of grain; consequently they are not advisable unless the fodder is of sufficient value to offset the loss of grain.

Corn for silage is harvested when it is somewhat immature. The grains should have passed the milk stage and glazed to some extent. The stalks will still be partly green. In case the corn cannot be cut until a little past this stage, the silage should be wet down in the silo. A corn-binder is very useful for cutting corn for silage, as the bundles can be hauled to the silo as soon as they have been harvested. They are prepared by means of a silage-cutter, a machine that cuts the stalks into small pieces and elevates them to the top of the silo. They fall to the bottom and, as the silo fills, the mass of material is kept level by men with rakes or forks stationed for that purpose in the silo. Figure 43 shows a typical silo-filling scene. Notice the bundles of corn, the silage-cutter, the pipe for elevating the cut corn, and the tractor that furnishes the power.

58. Pests of corn. — Several insect and a few fungous pests by their ravages reduce considerably the yield of corn in the United States. Among these pests are corn root-worms, corn root-louse, wire-worms, cutworms, white-grubs, corn ear-worms, grain-weevils, chinch-bugs, army-worms, corn-smut, and ear-rot.

Corn root-worms. — Among the most troublesome of the insect pests of corn are the root-worms, two species of which are known, the Northern, or Western, and the Southern. The eggs of both species are laid in the ground in the fall. They hatch about the last of June or the first of July and soon enter the tip of the corn root and burrow back and forth lengthwise. Often five or six worms are found in a root and Holden reports 465 from a hill. The roots injured by the worms die and the plants become so weakened that they blow over easily. The worms when full-grown are about one-third of an inch in length, about as large around as a pin, and are practically colorless. They go into the pupa stage in late summer and soon emerge as beetles about an inch in length. The beetles of the Northern worm are grass-green in color; those of the Southern species

are yellowish-green with twelve black spots on the back. The mature insects feed on the silk and on the kernels at the tip of the ears. Crop rotation helps to destroy them. The Northern worms feed on no other roots than those of corn; consequently depriving the larvæ of their food will starve them. The Southern worms feed on some other species of plants; nevertheless their principal food is corn roots and rotation is, therefore, a benefit. Experience in the corn-belt shows that when a system of crop rotation is practiced, little damage is done to the corn by this insect, but when corn follows corn the damage is likely to be excessive.

Corn root-louse. — Like all members of the plant-lice family, the corn root-louse gets its nourishment by sucking sap from the plants. The plant, deprived of some of its food, soon weakens and, if the ravages are excessive, may die. The lice are smaller than the head of a pin and are found in large numbers on corn roots. There are from nine to twelve generations a year and, as may be inferred, the damage done by such a large number of insects is very great. Lice are always found associated with ants which guard and care for them and in return for this service the lice excrete through two tubes on the back of the abdomen a sweet liquid known as honey-dew on which the ants feed. The finding of ants near a hill of corn nearly always means that lice are at work on the roots. The effect of the insects is to retard growth and to produce a yellowing of the corn. Often the tips of the leaves will have a purplish tinge and the stalks a slightly reddish color. As the corn is retarded in growth, it is likely to be caught by early frosts, the yield will be poor, and the quality not of the best. When the corn roots become woody, the ants transfer the lice to roots of smartweed and foxtail. Weedy fields are for this reason often badly infested with the insect. The principal remedies are rotation of crops and early and clean cultivation. Rotation of crops deprives the lice of their food and the ants will take them away. Clean cultivation destroys smartweed and foxtail and, if done

before the corn plants are above the ground, hinders the ants from transferring the lice to the roots of the corn.

Wire-worm. — Another pest of corn is the wire-worm. These are the larvæ of click beetles. They damage the corn by eating the seed in the ground and by boring and eating the stems and roots of the young plants. The larvæ of different species vary in length from one-half to one and one-half inches. The eggs are laid in sod land and the insects require from three to five years to reach the adult stage. When corn follows grass in a field that is badly infested with the wire-worms, the damage to the corn is likely to be great. One remedy is to keep the land in grass only a short time, perhaps one or two years, as the worms are always more numerous in old sod fields than in those that have been in grass only a short time. Fall plowing also helps to lessen the numbers of both the beetles and the larvæ.

Cutworms. — Often cutworms are troublesome in corn fields. They are larvæ of many different kinds of moths. During the summer the moths lay eggs on grass leaves and the larvæ soon hatch and feed on the green leaves. During the winter they remain in the ground and in the spring come out and feed on growing plants, cutting off the plants just above the ground. They are found in large numbers in fields that have been in grass a long time. Thus one way to control these worms is to practice a rotation with grass kept on the ground only one or two years. Fall plowing is an aid, as it exposes them to the winter weather and kills the vegetation on which they feed in the early spring. On small areas the worms can be poisoned, but this method is not practicable on large areas. A mixture made according to the formula, forty pounds of wheat bran, two quarts of molasses, and one pound of paris green, is moistened with water and a teaspoonful placed near each hill of corn. The molasses attracts the worms and, if the mixture is eaten, the poison kills them.

White-grub. — The larvæ of May beetles, or June bugs,

known as white-grubs are often a pest in corn fields. They feed on the roots of the young plants. It has been found that they are less numerous in fields that are kept in sod only a short time than in old sod fields and the remedy, therefore, is a short rotation for the grass crop. Fall plowing is also an aid as it exposes the grubs to the weather and destroys the plants they would feed on in early spring.

Corn ear-worm. — An insect known as the corn ear-worm that is about one and one-half inches in length and varies in color from green to brown does considerable damage to corn. It is the same as the cotton boll-worm. The worms are covered with stripes of practically the same color as the body and on each segment are eight black spots from which short hairs extend. This worm is the larva of a large, grayish moth which usually lays the eggs on the silk or leaves of the plant. The larvæ feed principally on the tip of the ear and destroy the grain, doing damage by providing a place for mold, rot, and grain-weevils to enter the ear. They sometimes feed also on the upper leaves of the plant. These worms when on sweet corn very much lessen its value. No very effective remedy has been found, although it is claimed that late fall plowing helps to reduce their number.

Grain-weevil. — A serious pest of corn, especially in the South, is the grain-weevil. The insects attack the matured grain in the fields and also in the crib after the corn has been harvested. Not much can be done to stop their work in the field, except to resort to late planting and to decrease the number of ear-worms. Early varieties of corn are more susceptible than late ones. To combat the insects in stored grain, fumigation with carbon disulfide is employed. This is a liquid that evaporates quickly when exposed to the air; in the gaseous form it is heavier than air and for this reason should be placed at the top of an inclosure to be fumigated. Tight bins are necessary. For shelled corn twenty pounds of the carbon disulfide is used for each thousand cubic feet of space in the inclosure

to be fumigated. It may be placed in shallow vessels on top of the corn or be poured on the pile, which should be covered with a heavy cloth and left undisturbed for twenty-four hours. Carbon disulfide is very inflammable and all fire should be kept away during the fumigation.

Fig. 44. — Corn-smut.

Migratory insects in corn. — Migratory insects that sometimes damage corn are chinch-bugs and army-worms. They can often be prevented from entering a corn field by throwing two furrows together about the field and maintaining in the ridge formed at the top of the furrow-slices a dust barrier by means of dragging a log along the ridge. Holes dug at intervals in front of the furrows on the side from which the insects are approaching will catch many of them as they try to get over the barrier, and water with a little kerosene placed in the holes will kill the insects.

Corn-smut. — The most troublesome fungous disease of corn is smut. It appears in black masses of spores on any part of the plant except the roots, but is usually found on the ears or tassels. Fig. 44 shows a smut-infested ear. Warm moist

weather is favorable for the growth of the spores and for this reason the disease is more prevalent during some seasons than others. About the only way to combat it is to go through the fields two or three times during the growing season and collect the masses. This would be worth the time only in a badly infested field.

Ear-rots. — Several kinds of ear-rots are found on corn. Of these the dry ear-rot is the most common. This affects cob, kernels, and husks. The ear becomes dark in color, except for mold between the rows of kernels. The best remedy is to burn the diseased ears as they are collected at harvest time and, on badly infested fields, to burn the stalks. The spread of the different rots is more prevalent in warm moist seasons than in dry ones.

QUESTIONS

1. Describe and compare the four chief types of corn.
2. When mature ears are desired why should a farmer select home-grown seed corn for planting?
3. Which is better, selection of seed corn from the field or from the crib? Why?
4. Why should a farmer test the seed corn that he expects to plant?
5. Describe briefly an ideal seed ear of dent corn.
6. When is corn usually planted in your vicinity? How does this compare with the time a hundred miles north or south of you?
7. Why should a corn-planter be tested before planting the field to corn?
8. Tell of the benefits of frequent shallow cultivation of a corn field. Why should deep cultivation be avoided?
9. Give the life histories of the Northern and of the Southern corn root-worms.
10. What remedies are used to combat the corn root-louse?

EXERCISES

1. **Characteristics of corn.** — Examine carefully ears of dent, flint, pop, and sweet corn and write in your notebooks the characteristics of each. Remove a few kernels of each kind of corn and compare them as to size, shape, flintiness, and size of germ. Soak the kernels

in water for a few hours. Cut part of them lengthwise of the germ and notice the depth of germ, the hard and the soft endosperm, and the color of the seed-coat. Cut the others crosswise of the germ and notice the width of germ and the hard and the soft endosperm.

In the fall soon after school opens visit fields of the different types of corn found in your vicinity and observe the character of growth of each, the root development of the plants, and the character of the stalks and the leaves.

2. **Percentage of stand.** — Count the stalks in an average square rod of a field of corn and compute the percentage of stand compared with a perfect stand.

3. **Harvesting and storing corn.** — On a field trip when corn is being harvested in the vicinity, study and write descriptions of the methods of harvesting and storing of the crop as practiced by different farmers.

4. **Gathering seed corn.** — Every school where agriculture is studied will require a supply of seed corn for use in the class-room work. In order that the best methods of securing and caring for the seed may be practiced, none of the details given on the previous pages should be neglected. When securing the seed for the school, go through the field at the proper time in the fall with a packing bag over the shoulder and select the ears. Pupils should follow this plan for their home farms and often the teacher can arrange to have the school select seed ears for persons who have no pupils attending the school. By following this plan the school increases its value to the community. A portion of the seed ears gathered should be reserved for use in class-room work.

5. **Caring for seed corn.** — After the seed ears are gathered, string them as shown in Fig. 41, place them on wire racks as shown in Fig. 42, or plan some other way of arranging them for drying. Store the ears in a cool, dry place where they are free from mice and rats and see that they are protected from grain moth and weevil.

6. **Testing seed corn.** — Make several sawdust-box and rag-doll testers. During the winter test the seed that has been gathered in the fall. Compare the results of both testers by testing lots of the same seed in both. Make a record of the time necessary to test the corn and compute the cost, figuring the usual price paid for farm labor in your vicinity.

7. **Judging corn.** — When scoring corn a certain standard of perfection is set up as an ideal and the ear or exhibit is selected according to this standard. Beginners usually make use of a score-card, but after they have had some experience, the score-card is no longer used, the ear or sample being judged without it. A score-card may be defined as a

description of an ideal ear with the various qualities arranged in logical order and given numerical ratings, the total of which is one hundred. Score-cards are useful in making a logical study of the different qualities and in emphasizing their relative importance. The ratings are arbitrary and, as different persons will not give the same weight to all of the different qualities, the cards are not uniform. However, they serve their purpose when they teach the pupils to observe closely the various qualities and point out their relative importance. Many of the state agricultural colleges furnish score-cards to teachers through their extension departments. When these can be secured they should be used, because they are adapted especially to the work in the state. On page 128 is given a score-card from United States Department of Agriculture Bulletin 281. This is a very good card and can well be used in schools where cards of local adaptation are not available.

Dealers in agricultural laboratory supplies furnish score-cards at a very nominal price and often these are purchased in quantities by school authorities and used in the classes.

When scoring a sample, a cut, or deduction, should be made for each ear deficient in each quality listed in the score-card. Suppose a ten-ear sample is to be judged and ten points is given for a quality, a cut of one point should be made for each ear badly deficient in this quality. If five points is given for a quality, a cut of one-half a point is made. If twenty-five points is given, a cut of two and one-half points is made. In case the ear is only slightly deficient in a quality, the extreme cut is not made, the ears being cut according to the judgment of the scorer.

The general practice in scoring a sample is for the scorer to draw toward him ears that require no cut and push away from him those that need the full cut. Thus three classes are made and it is easy then to make a fair estimate of the amount to cut the whole sample.

Using the score-card, practice scoring and judging as follows. With a ten-ear exhibit before you, select the ear that is best in maturity and seed condition. Select the ear that is poorest in this respect. Arrange the ears of the samples in order, one, two, three, and so on, with only this quality considered. Proceed in like manner with all the other points on the score-card. Next, score the sample, taking into consideration all the points. Follow this by scoring three samples and arranging them in order according to the total scores. After having had experience in scoring several samples, arrange three samples and place them in order by comparing them without using the score-card. Next, score these same samples and compare with your previous placing. Continue this comparative judging until you can place samples in order accurately without using the score-card.

Score-card for Corn

Variety .... Exhibit No. ......

Points	Perfect	Scorer's	Corrected
Maturity and seed condition . . . . . To be of value for grain, corn *must* mature and produce good, hard seed.	25	....	....
Uniformity . . . . Ears should be alike in shape, size, color, indentation, and size of kernel.	15	....	....
Kernels . . . . Flat side, slightly wedge-shaped with large, smooth germ. Edge, with parallel sides and of medium thickness. Not chaffy.	15	....	....
Weight of ear . . . . Dent varieties, as usually planted, produce only one ear per stalk, hence yield per acre depends largely upon weight of shelled corn per ear.	15	....	....
Length and proportion. . . . . Varies with locality and variety. Experiments show that a continued selection of short, thick ears reduces the yield.	10	....	....
Butts . . . . The base of the ear should be covered with even-sized kernels in straight rows which are a continuation of those at the center of the ear. The shank should be large enough to support the ear and no larger.	5	....	....
Tips . . . . Should be covered with kernels of the same depth and be in rows which are a continuation of those at the center of the ear.	5	....	....
Space between rows . . . . Should be very slight and in straight lines.	5	....	....
Color . . . . The color of both grain and cobs should be uniform, showing trueness to type or strain.	5	....	....
Total	100	....	....

Remarks ....

Name of scorer .... Date ....

8. **Testing the corn-planter.** — In the spring just before corn planting time, visit several farms and test the corn-planters found there, as described on a previous page.

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CHAPTER VII

SMALL GRAINS

Wheat

Distribution and characteristics of wheat.
Kinds of wheat.
    Spelt group, durum wheat group, bread wheat group.
Uses of wheat.
Soils for wheat.
Seeding of wheat.
    Rate of seeding.
    Methods of seeding.
    Depth of planting.
Harvesting of wheat.
Weeds of wheat fields.
Insects of wheat fields.
    Hessian fly, chinch-bug.
Fungous diseases of wheat.
    Loose smut, stinking smut, rust, scab.

Oats

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Rice

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Buckwheat

Distribution and characteristics of buckwheat.
Cultural methods.

THE staple small grain is wheat, the flour of which is baked into the many kinds of bread so much prized by the Caucasian races. Vast areas of North America are devoted to the growing of this cereal and many machines have been devised to aid in its culture and harvesting. The milling of wheat into flour is itself a large industry and gives employment to thousands of persons. In many parts oats is an important crop. It is the most used of any of the grains as feed for horses, and in the form of oat-meal is an important article of human food. Rye is not extensively grown in the United States, but in some regions it is an important crop. The grain is used chiefly as live-stock feed, although some of it is milled into flour for human consumption. Barley is the malt-producing grain. As will be learned later, about half the barley grown in the United States has been used for the making of beer and other malt beverages. As a live-stock feed, barley has considerable value and in some regions is fed extensively. Rice in Asia feeds millions of people, but its production in the United States is lim-

ited to areas in some of the Southern States and in California. It is an important article of food and its use by American people is increasing. With the extensive export of wheat to feed European peoples at war, the other grains are assuming additional importance as human food.

WHEAT

59. Distribution and characteristics of wheat. — Nearly all countries having a temperate climate produce wheat. The United States, Russia, France, and India are the largest producers. This cereal is also grown extensively in Austria-Hungary, Italy, Argentina, Germany, and Canada. In the United States the five leading wheat states are North Dakota, Minnesota, Kansas, South Dakota, and Nebraska.

Wheat is an annual belonging to the grass family. The spikelets are arranged alternately on the rachis, or top of the stem, forming a spike. The culm in most varieties is hollow except at the nodes. In a very few varieties, however, the stem is partly filled with pith. The length of stem varies considerably in different varieties and when the crop is grown on various soils. Some varieties have stems that reach a height of two and one-half to three feet, while others on the same soil will grow to be four or five feet tall. Wheat tillers freely, often one seed producing a dozen or more stalks. The leaves are rather short and narrow and vary in different varieties in length, width, smoothness, and prominence of veins. The leaf-sheath is hairy as in rye; whereas in barley and oats it is smooth. As the plant matures the leaves wither and when the seeds are ripening only the top of the stem and the upper leaf are green. The roots are fibrous and are found mostly in the upper fifteen to twenty inches of soil. When a kernel of wheat sprouts in the ground, three temporary roots branch from the hypocotyl and make up the temporary root system. After the plumule is above the ground, permanent roots start from a node of the stem. The temporary roots soon wither

and the plant obtains its nourishment wholly from the permanent roots. Deep planting does not mean deep rooting, because the permanent roots form about an inch below the surface no matter how deeply the temporary roots, which come direct from the seed, develop.

The grains of wheat are oblong with a deep groove on one side and a brush of short hairs at the tip. Variation in size, shape, color, and hardness is found in different varieties. The endosperm makes up about 85 per cent of the kernel and most of this enters into flour. The outside covering of the kernel consists of three layers which make up the bran. This is about 5 per cent of the kernel and is used chiefly as live-stock feed.

Fig. 45. — Heads of beardless winter wheat. 1, Fultz; 2, Leap prolific; 3, purple straw; 4, Poole; 5, mealy; 6, Dawson golden chaff.

60. Kinds of wheat. —According to the time of year it grows, wheat is known either as winter or as spring. Seed of winter wheat is planted in the fall and harvested early the next summer and seed of spring wheat is planted in the spring and harvested the same year.

Wheat may also be classified as beardless and bearded. Figs. 45 and 46 show heads of both classes.

Botanically wheat may be divided into eight species and sub-species, known as einkorn, emmer, spelt, poulard, durum, polish, common, and club. These may be grouped as follows:

Spelt group. — Einkorn, emmer, spelt. Grain inclosed in glumes, a portion of which adheres to grains after threshing. Grains make poor flour. Not extensively cultivated. Einkorn is thought to be one of the first of the cultivated types. It is not grown in America. Emmer is grown rather extensively in the northern part of the Great Plains region. It is used largely as a stock food. Spelt is not grown in the United States. (See Fig. 47.)

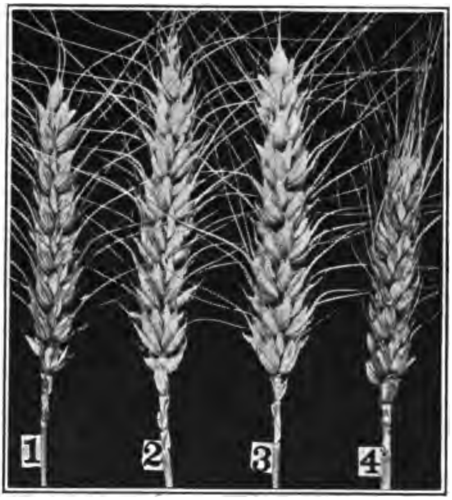

FIG. 46. — Heads of bearded winter wheat. 1, Mediterranean; 2, Virginia; 3, winter fife; 4, early Genesee giant.

Durum wheat group. — Poulard, durum, and polish wheats. Grains free when threshed. Used principally in the manufacture of macaroni and other paste foods. Adapted especially to dry climates. Durum is the principal wheat of this group. Introduced into the United States by the Department of Agriculture and now grown extensively in the Great Plains region.

Bread wheat group. — Common and club wheat. Grains free when threshed. Common wheat, the kind most extensively grown, is used principally for making flour. Figures 45 and 46 show common wheats. Club wheat has a short compact head and is especially well adapted to conditions in the Pacific Coast region, where it is grown extensively. Like common wheat, it is used for making flour. The bread wheats are grouped commercially according to color, hardness, and time of growth, as soft wheat, soft red, medium red, hard winter, and hard spring wheats.

As a general rule, the soft wheats are light and the hard wheats are dark in color.

61. Uses of wheat. — By far the largest part of the wheat grown in the world is used for the manufacture of flour, which is made into bread and paste foods, like macaroni. Certain prepared breakfast foods are made from wheat and a small quantity is fed to live-stock, but usually this latter is of poor

FIG. 47.—Heads of German emmer, spelt, and einkorn. 1, black winter emmer; 2, white beardless spelt; 3, black winter emmer; 4, black bearded spelt; 5, double einkorn; 6, spring emmer.

quality and not suitable for flour. In the milling of flour, many by-products result that are employed chiefly as live-stock feeds. The straw is used as roughage feed and bedding for live-stock.

62. Soils for wheat. — Wheat has been grown successfully on most kinds of soil. It is important to have the soil in good tilth. In the case of heavy soils, more work is necessary to bring them into good condition than with loamy soils, but if heavy soils are well tilled they can be made to grow good crops of wheat. Sandy soils for this crop must be well supplied with

humus. The organic matter in the soil must be in a more advanced stage of decay than for corn. In many rotations wheat follows corn, which in turn has followed sod that has been manured. In these rotations the manure and sod are well decayed by the time the wheat is planted. Commercial fertilizer is often used profitably for wheat, especially in the older farming regions; the plants seem to respond readily to the available food in the fertilizer.

Fig. 48. — Grain-drill.

63. Seeding of wheat. — Winter wheat should be sown early enough in the fall to provide for a good root development before freezing occurs. The general rule in northern sections is to plant six or eight weeks before the freezing weather of winter usually begins. Where the Hessian fly is prevalent, especially in the South, the seeding is often delayed until after the first killing frost. (See paragraph 66.) Spring planting is best done as early as the conditions of soil and weather will warrant, because the plants make their most satisfactory growth in the cool weather.

Rate of seeding. — The rate of seeding varies somewhat with

the type of soil, more seed being required on heavy soils than on light ones. This is because the plants tend to tiller more freely on light soils and thus make more stalks. The average seeding is six pecks to the acre, but often eight pecks are used. In the dry-farming sections of the West, only three to four pecks are recommended, as the soil in these parts is warm and loose and the plants tiller freely; thin sowing also gives large plants that stand the dry climate better than smaller ones.

Methods of seeding. — Wheat is often sown broadcast, but better results are obtained by planting with drills. A more even stand can thus be secured, as the seeds are all covered to about the same depth. Another advantage is that they are planted in shallow furrows and are not so likely to be heaved out of the ground by frost. With the drill, fertilizer and grass seed can be sown

FIG. 49. — Grain-binders in a wheat field.

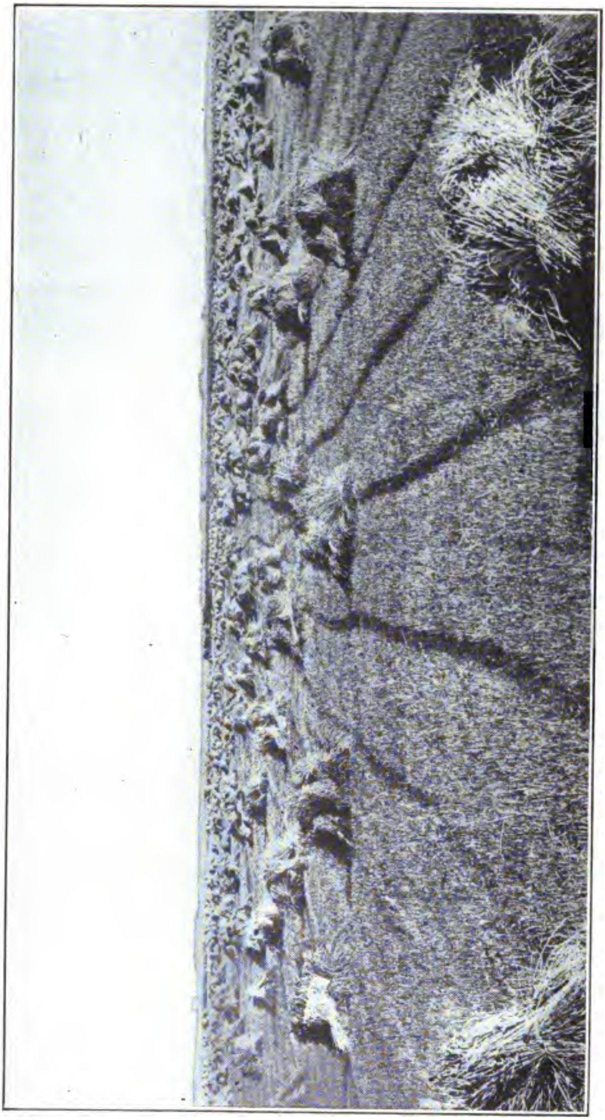

FIG. 50. — A field of wheat in shock.

at the time of wheat planting. Figure 48 shows a common type of grain-drill. (See paragraph 226.)

Depth of planting. — Deep planting is not advised for wheat; from one to two inches is enough. As explained previously, the plants put out permanent roots near the surface no matter how deep the seed is planted. In soils of poor tilth, however,

FIG. 51. — Self-rake reaper.

somewhat deeper seeding is necessary than in well prepared soils, because in the former the moisture will be insufficient in the surface layer to germinate the seed.

64. Harvesting of wheat. — In most sections wheat is cut with binders (Fig. 49). These implements cut the mature plants, bind them into bundles, and deposit the bundles in piles on the ground. After the grain has been cut men follow through the fields and place the bundles in shocks (Fig. 50). In hilly regions an implement known as the self-rake reaper (Fig. 51) is often employed for cutting wheat. Reapers cut

the grain and deposit it in piles, but do not bind it in bundles. It is afterwards bound by hand. Before binders were perfected, reapers were much used in all sections, but in recent years they have not often been employed, except when there is danger of binders tipping over because of the hilly ground.

In the West where the grain is allowed to become fairly ripe before it is cut and where large areas are planted to wheat, grain-headers are used extensively for cutting wheat. These machines remove the heads only, leaving the straw standing in the field. Combined harvesters and threshers are also used in some parts of the West. They cut the heads and convey them to a thresher that is attached to the machine. The ripe conditions of the grain and the dry climate make the cutting and threshing possible at one time.

On small areas or on very hilly ground, grain-cradles are sometimes used for cutting wheat. A cradle is similar to a scythe, but in addition to the blade it is provided with long wooden fingers that carry the grain and deposit it in swaths. The grain is bound into bundles by hand. Before the advent of harvesting machines, cradles were used extensively for all small grains.

Wheat, except that cut by the combined harvester and thresher, is usually threshed by machines that are operated by horse power, steam, or gas engines. The bundles or heads of grain are run through the machine which removes the grain from the straw and chaff. The grain comes out of one opening and is measured automatically. The straw and chaff come out of another opening; the straw is usually stacked and saved for stock feed or bedding. (See paragraph 229.) A typical threshing scene is pictured in Fig. 52.

In some sections the grain is threshed direct from the shocks; in others it is stacked or placed in a mow and threshed later. If the weather is dry and the grain can be threshed soon, threshing from the shock secures the grain in good condition.

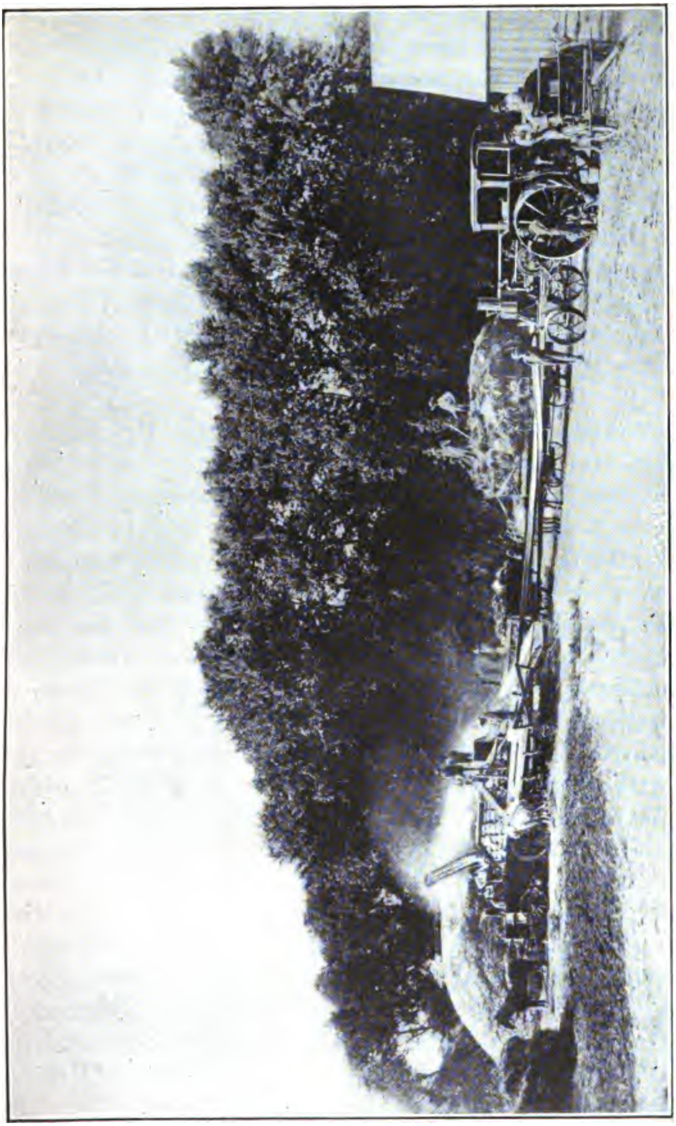

FIG. 52. — A threshing scene.

However, if the grain becomes wet in the shock, the yield of good produce will be lessened. The grain must go through a sweat, which may take place in the shock, stack, or mow, or in the bin after the grain is threshed. The sweating causes heat and if the heat becomes too intense the grain will char, or blacken, thus destroying its quality. If the grain is placed in stack or mow when it is wet or if many green weeds are bound with it, excessive heating may occur.

Threshed grain may be stored in any dry bin. If the grain in bins becomes very hot, due to sweating, it should be spread out to prevent charring. In the West, on account of the dry climate, grain may be safely stored in sacks in the field.

65. Weeds of wheat fields. — On account of the seeds getting into the threshed grain and later into the flour, weeds in wheat fields are especially undesirable. Among the troublesome weeds are chess, or cheat, darnel, cockle, wild garlic, pigeon-weed, and wild mustard. Chess and darnel seed can be removed from seed wheat by means of a fanning-mill. Cockle seed are about the same size and weight as wheat grains and for this reason are not readily separated by a fanning mill. About the only way to combat this weed is to pass through the field and pull up the plants when they are in blossom. The flowers are pink, making the plants easily distinguishable. Wild garlic and pigeon-weed are combated by planting infested areas in some other crop for a few seasons. Wild mustard seed is often found in seed wheat and, of course, such seed should not be planted. When plants are found in the field they should be pulled up; they can be distinguished by their yellow, four-petaled blossoms. Spraying the fields with a solution of iron sulfate has in some instances been found effective in combating mustard. The solution kills the mustard plants, but not the wheat. The formula used is eighty pounds of iron sulfate to forty gallons of water. This is spread at the rate of fifty gallons to the acre.

66. Insects of wheat fields. — The Hessian fly and chinch-bug are the most injurious insect pests to the wheat.

The *Hessian fly* is a blackish insect about one-tenth inch in length. The larvæ eat the stems of young wheat plants, causing them to tumble over. The methods of controlling this pest are summarized by F. M. Webster in Farmers' Bulletin 641:

"In the fall-wheat-growing sections sow the best of seed in thoroughly prepared, fertile soil after the major portion of the fall brood has made its appearance and passed out of existence, and, if possible, sow on ground not devoted to wheat the preceding year.

"In the spring-wheat section late seeding will not apply. It seems likely, on the contrary, that the earlier it is sown in spring the less it will suffer from the Hessian fly. But good seed and a well-prepared, fertile soil are as essential there as elsewhere."

The *chinch-bug* hibernates during the winter in grass or under piles of weeds, trash, and rubbish and in the spring the females fly to wheat fields to lay eggs on the base of the plants. These eggs hatch in about twenty days and the larvæ feed on the wheat. They live on the wheat until it is harvested, when they migrate to corn or oats. The adults have wings, but they travel on foot from the wheat fields. This fact makes it possible to use barriers, as explained elsewhere, in protecting the corn or the oat fields. The insects that reach these fields lay eggs there and a second brood hatches. The adults of this brood fly to grass land and rubbish piles and remain there during the winter. The control of the pest in wheat fields is accomplished by burning rubbish piles early in the spring before the adults lay their eggs.

67. Fungous diseases of wheat. — Smuts, rusts, and scab are fungous diseases that attack wheat.

Smut. — Two kinds, loose smut and stinking smut, are destructive to wheat (Figs. 53 and 54). Loose smut destroys

FIG. 53. — Loose smut of wheat. Comparison of sound head and smutted heads at four stages of development.

both grains and glumes and at harvest time only the naked stem of the plant remains, the spores having been scattered about the field. Figure 53 shows this condition very plainly. The spores mature when the grain is in blossom. They are scattered about the field and if they lodge on a blossoming head of wheat they germinate and penetrate to the inside of the grain. Stinking smut destroys only the kernel, the glumes still remaining around the spores. The outside of smutted grain is intact, but the inside, instead of a wheat grain, is a mass of spores. The smut balls often found in threshed grain are masses of stinking smut, not loose smut. The smut balls are shown in Fig. 54. When the grain is threshed, the spores are scattered. They adhere to the outside of the grain of wheat, especially in the crease or among the tuft of hairs at the upper end.

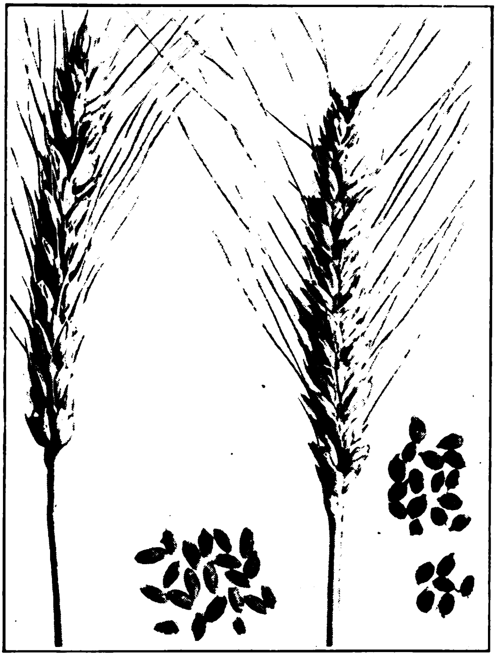

Fig. 54. — Stinking smut of wheat. Comparison of sound head and sound kernels with smutted head and smut balls.

The fact that the spores of loose smut are on the inside of the grain and those of stinking smut are on the outside makes the treatment for the two diseases different. It has been found

that the spores of loose smut are killed by a temperature of 133° F., which is four or five degrees lower than will destroy the germ of the wheat. To treat the seed place the grain in a sack and soak it, sack and all, in cold water for six hours to soften it. Then have ready a tub of water at 133° F. and place the sack in the water, leaving it there for five minutes. Remove the sack, empty the grain, and spread out to dry. Some of the germs of wheat may be injured by the high temperature and to counteract this loss a little more seed should be sown.

What is known as the formalin treatment is used to combat the stinking smut of wheat. The formalin, which should be of 40 per cent strength, can be purchased at a drug store. Dissolve at the rate of one pound, or one pint, to fifty gallons of water and use one gallon of the solution for each bushel of wheat. Spread the wheat in a long pile on a tight, smooth floor and sprinkle the solution over the pile. It is a good plan to have one person shovel the pile over while another uses the sprinkling can. After the pile is wet cover it with bags or blankets to keep the fumes of the formalin in the wheat and allow it to remain covered several hours. Next spread the grain out to dry and when dry be careful to place it in clean bags. Turn the bags inside out and sprinkle some of the formalin solution on them to kill any spores that may be in the bags. When ready to plant the grain, sprinkle the seeder-box with the formalin solution to kill any germs that may be there.

Rusts are responsible for considerable damage to wheat, especially in humid climates. They are more prevalent if the weather is warm and moist than if it is dry. Two kinds are destructive to wheat — the leaf rust and the stem rust. These diseases may be known by the rusty brown or blackish spores that attack the plants during growth. No remedy is available, but some varieties of wheat are more rust-resistant than others; consequently, as a preventive measure, it is well to

plant a rust-resistant variety. The United States Department of Agriculture or the experiment station of each state can give advice as to varieties for each particular region.

Wheat scab attacks the head of the grain. It is known by a reddish spot found at the base of the diseased glumes. Scab does not usually cause great loss, although at times much shriveled grain results from the disease. There is no remedy, but, of course, seed from an infested field should not be planted.

OATS

68. Distribution, yields, and characteristics of oats. — The principal oat-producing countries in order of production are: United States, Russia, Germany, France, Austria-Hungary, and the United Kingdom. In the United States the Central and North Central States are the largest producers. Iowa and Illinois grow about a fourth of the oats of the country. Other states having large oat-producing areas are Wisconsin, Minnesota, North Dakota, South Dakota, Michigan, Ohio, Indiana, Nebraska, Kansas, Pennsylvania, Texas, and Missouri. Oats are grown in many of the Southern States and, although the acreage is not large, it is rapidly increasing. The average yield of oats in the different countries varies considerably. From 1900 to 1909 the yields in bushels were as follows: Germany 50.7; United Kingdom 44.3; France 31.6; Austria-Hungary 30.2; United States 29.3; Russia 20. The yield in the United States is very low. With more attention given to the farming of oats, the average yield in this country could easily be doubled.

The plant is an annual with jointed stem, blade-like leaves, and a fibrous root system. The height of stem varies from two to five feet, averaging about three feet. The leaves are somewhat broader than those of wheat. The grain-bearing portion is a panicle which consists of a central stem, along which are nodes from which spring single branches that bear the spikelets (Fig. 55).

69. Kinds of oats. — Oats are classified as spreading and side oats. In the former the branches bearing the spikelets are distributed on all sides of the stem; in the latter the branches are all on one side (Fig. 55). Oats are grouped as winter and as spring, depending on the time of year grown. They are also classified as early and as late varieties, according to the length of time they require for development, not according to the time they are planted. The usual variation of the growing season ranges from 90 to 120 days. As to color, oats are classified as white, black, red, yellow, and gray.

Fig. 55. — Spreading oats and side oats.

70. Uses of oats. — The grain is particularly useful for horses and is also fed to some extent to sheep, cows, and hogs. The straw makes good roughage and bedding for live-stock. The plants are sometimes cut for hay and when grown with field peas are good for soiling purposes. Oats make a satisfactory temporary pasture. In the form of rolled oats, the grain is used extensively for human food. The best grades only are desirable for this purpose and such grades bring a good price on the market.

71. Climate and soils for oats. — A cool, moist climate is most desirable for oats. In the United States they make their best yields in the northern part of the country. However, they are grown successfully in the South, although the yield and bushel weight is somewhat less than in the North. Only rust-proof varieties should be planted in the South.

Loam and clay soils that are not too heavy usually produce better crops than sandy loams, because of their greater water-holding capacity, but sandy soils containing abundant plant-food and having fairly stiff subsoils can be made to produce good oats. Heavy soils are too cold for oats and do not produce good crops. Because of their tendency to lodge, oats should not be grown on exceedingly rich soil.

72. Preparing the ground for oats. — Less preparation is given to the ground for oats than for any of the other cereals. In the corn-belt states this is due to the desire of the farmers to get the crops planted early. Oats, being hardy, seem to stand this treatment better than other cereals. Often the ground receives no preparation before the oats are planted. Some farmers sow the oats broadcast and cover them by means of a disk. Others use a disk drill to plant the seeds. Still others go over the ground with a disk or harrow and level it before planting the grain. At times the land is plowed and harrowed before the seed is sown. The best method to follow varies with conditions. If the ground is very weedy, plowing or disking may be profitable; in other cases the difference in yield may not pay for the extra cost of preparation. Experience in a particular region is the best guide, and often it will pay farmers to experiment on their own fields to find out which method seems to give the greatest net profits. In the South good preparation of the seed-bed is profitable; plowing and disking the land to make the soil of good tilth before the seeding has given good results.

73. Planting the seed. — Oats are often broadcasted and covered by means of a disk or a spike-tooth harrow, but better

results are obtained by seeding them with a grain drill, as there is likely to be a more uniform stand and a saving of seed.

What is known as the open-furrow method of planting oats is used in some sections of the South to prevent winter-killing of the plants. One practice consists in sowing the seeds in the bottom of furrows eighteen to twenty-four inches apart made by a single shovel plow. A one-horse planter is used to drop the seed, which then grow at the bottom of the furrow where they are protected from the heaving of the ground which so often occurs in the South, especially on wet soils. Another practice is to use a special drill made for sowing between rows of standing crops. These implements plant three furrows at a time and are just wide enough to go between the cotton rows. The seed is planted in the standing cotton in the autumn.

The average acre-rate of seeding for oats is eight or nine pecks, but often as low as six pecks or as high as ten or twelve pecks are sown. Varieties with large kernels should be sown more thickly than those with small kernels. Oats tiller freely and for this reason a thin seeding often gives good results.

74. Harvesting of oats. — Usually oats are cut with a grain-binder. If the grain is ripe or in the hard-dough stage, the bundles may be placed in round shocks. These should be capped to protect the grain from the weather. If the grain is green or many weeds are bound into the bundles, they should be placed in long shocks so that air and sunshine can penetrate. The grain should be dry when threshed; it threshes better and there is less danger of heating and molding.

75. Enemies of oats. — The weeds that are the most troublesome in the oat fields are wild mustard and chess. The method of combating these in oats is the same as in wheat. The principal insect enemies of oats are chinch-bugs and army-worms. The method of control of these pests has been discussed elsewhere. Rust attacks oats and in some sections does considerable damage in warm seasons. Rust-proof varieties of oats should be used in regions where rust is likely to

be prevalent. Two smuts attack oats, loose smut and covered smut. In the former the panicles of the plant become masses of black spores. The covered smut does not attack the glumes, only the oat grains. These smuts are controlled by the formalin treatment described for stinking smut of wheat.

RYE

76. Distribution and characteristics of rye. — Europe is the principal rye-producing country, supplying about nine-tenths of all the rye grown in the world. North America is second, growing about one thirty-eighth as much as Europe. Asia is third and Australasia fourth, each with small quantities when compared with Europe. In Germany and Russia much more rye is produced than wheat. The United States produces less than 3 per cent of the rye crop of the world. The heaviest rye-producing states are Pennsylvania, Michigan, Wisconsin, and New York. The bulk of the production is in the eastern half of the country.

Rye resembles wheat in its botanical characters, is used for similar purposes, and is cultivated in much the same manner. It grows somewhat taller, the stems often reaching a height of six or seven feet with the spike six or seven inches long. Both winter and spring varieties are grown.

77. Uses of rye. — The principal use of rye is in the making of flour for bread. Much more rye bread is consumed in Europe than in America. Rye is also used in the making of whisky and the grain is a valuable stock feed. Green rye is used as a soiling crop and as pasture. Winter rye is one of the earliest green forage crops to be ready in the spring. If it is not too ripe when cut, rye makes fairly satisfactory hay. The straw, however, is not of much use as roughage for live-stock. It makes excellent bedding and is used largely in the manufacture of hats, paper, baskets, matting, padding of horse collars, and as packing material for glassware. As a green-manure crop, rye is of considerable im-

portance, because it will grow on poor soils and make abundant foliage.

78. Climate and soils for rye. — Rye has a wide climatic range; it grows well in both the northern and southern parts of the United States and it can be grown farther north than wheat. It will grow on all types of soils, if they are well drained, but does best on light loams or sandy soils. It grows better on poor ground than other cereals, and for this reason is often selected for the poorest fields of the farm.

79. Planting the seed. — The rate of seeding varies with conditions; when used for grain the usual acre-rate is about six pecks, and when used as a green-manure or soiling crop, about two bushels. As to the time of seeding, rye has a wide adaptation, varying in different sections and even in the same region. Usually it is seeded earlier than wheat, but it may be sown much later.

80. Harvesting of rye. — The implements for harvesting rye are the same as for the other small grains. The time of harvesting varies with the use to be made of the crop. When grown for grain, it is allowed to become fairly ripe. When the straw is to be sold for manufacturing purposes, the plants are cut very green. Properly cured it is tough and of a desirable color. The highest price on the market is secured if the stalks in the bundles are kept straight; in order to remove the grain and still have the stalks straight, special rye threshers are necessary. In many of these the head of the bundle is pushed into the machine and the bundle held until the grain has been removed, after which it is withdrawn and thrown to one side.

81. Enemies of rye. — Rye is not seriously troubled by insects and fungous pests. All the insects that attack wheat also attack rye, but they do less damage. Rusts and smuts do not seriously injure rye, but ergot is a fungous disease that often becomes troublesome. It attacks the grains and causes them to increase to three or four times their normal size and turn black. Live-stock, when fed on rye affected by ergot,

are often made sick. The use of seed free from ergot is a preventive measure; it is also advisable to plant some crops other than rye for at least three years on land that has grown rye badly affected by ergot.

BARLEY

82. Distribution and characteristics of barley. — The chief barley-producing countries are Russia, United States, Germany, Austria-Hungary, and Japan. In the United States about three-fourths of the crop is produced in California, Minnesota, South Dakota, Wisconsin, and North Dakota.

Barley is similar to wheat in appearance. It has, however, shorter stalks, broader leaves, and a different structure of the spike. The spikelets are inclosed in the hulls, and these, except in a variety known as hull-less, cling to the grain after it is threshed.

Two types of barley are common — the six-rowed and the two-rowed. In the six-rowed, there are six spikelets, each producing a kernel, at every joint along the stem, thus making six rows of grains up and down the head. In the two-rowed, three spikelets are produced at each joint as in the six-rowed type, but only one of the three produces a kernel. Thus there are two rows of grains along the head. Barleys are also classified as bearded and beardless and as winter and spring varieties.

83. Uses of barley. — About half of the barley grown in the United States is used for making malt, a product employed in the manufacture of beer and other malt liquors. Barley makes a desirable feed for live-stock. In the Pacific Coast States it is used largely for horse feed; in the Central States it is fed extensively to hogs, cattle, and sheep. When cut before the beards become too thick, barley makes a very good hay, and it is also frequently used as pasture for sheep and swine. The grain is used as human food in the form of pearl barley, barley meal, and barley flour.

84. Climate and soils for barley. — Although it can be grown successfully in rather moist regions, a warm, dry climate is best for barley. The crop can be produced successfully, however, in nearly all parts of the United States and in many sections of Canada.

Soils for barley must be well drained. Fertile loams produce the crop profitably, but on poor soils the yield of grain is low and the straw is short. In some regions in which alkali is prevalent, barley seems to do better than corn, oats, or wheat.

85. Planting the seed. — Somewhat better tilth of soil is necessary for barley than for oats. When it is to be planted in the fall, it is usually advisable to plow the land before seeding. However, when the crop is to follow corn or potatoes a good seed-bed is often made by disking and harrowing the land instead of plowing it. When barley is to be seeded in the spring, it is often a good plan to plow the land in the fall and work it with a harrow early in the spring. If the plowing is delayed until the spring, it should be done early and a mellow seed-bed made before planting the seed.

Barley may be either drilled or broadcasted, but drilling is preferable, as higher yields result and, in the case of winter barley, there is less likelihood of winter-killing. About six or eight pecks is the usual acre-rate of seeding when drilled and about ten pecks when broadcasted. In dry sections of the West a lower rate, from three to four pecks, gives better results. Spring-seeded barley is usually planted a little later than oats. Winter barley in the North is usually planted in September or the first part of October. In the South the seed is sown any time between September 1 and December 1, depending on the locality.

86. Harvesting of barley. — The grain should be in the hard-dough stage when cut. The straw and heads at this stage will be yellow. If cut too green the kernels will shrivel. The grain is cut in the same manner as described for the other cereals. Excessive weathering in the shock injures the ap-

pearance of barley and lessens its value in the market. To protect the bundles, the shocks should be made so that they are not easily blown over and a cap sheaf should be placed on the top of each. The grain should be threshed as soon as the bundles have dried in the shock and, if no threshing machine is at hand, it should be stacked rather than left in the shock too long. The stacking will protect it from the weather.

87. Enemies of barley. — The Hessian fly and the chinch-bug are insects troublesome to barley, and they are controlled as described for wheat. Several rusts attack barley, but it has been found that early-maturing varieties are likely to mature before much damage is done by rust. Thus the practical way to combat the rust is to use such varieties and plant the seed early. Both loose smut and covered smut attack barley; the former is combated by the hot-water treatment and the latter by the formalin treatment.

RICE

88. Distribution and characteristics of rice. — Asia is the chief producer of rice, for out of an average yearly production of 150,000,000;000 pounds, 135,000,000,000 are produced on that continent. The United States grows a comparatively small part of the rice of the world, the average yearly production being 700,000,000 pounds. Rice-growing in the United States is confined largely to restricted areas in Louisiana, Texas, Arkansas, California, South Carolina, and North Carolina.

Like other cereals, rice is a member of the grass family and has shallow, fibrous roots, jointed stems, and blade-like leaves. The grain is held in a panicle that is less open than the panicle of oats; the plants grow to an average height of four or five feet; the hulls remain attached to the kernels after the grain is threshed; and the kernel itself is white, hard, and vitreous. The grains are removed from the hulls by what is termed polishing.

89. Uses of rice. — The principal use of rice is for human food. It is one of the oldest crops of the eastern nations and

for many centuries has been their chief food. Rice polish, a by-product made in removing the hull, is a very valuable feed for live-stock. Rice bran is another by-product used for live-stock feed. It consists of the seed-coat of the grain and some of the hulls and polish. Rice hulls have little food value and are often used as packing material.

90. Climate and soils for rice. — Moist climates and long, hot, growing seasons are best for rice. Most of the crop is grown on low-lying areas that can be quickly irrigated and quickly drained, although some varieties are grown on high ground without irrigation.

91. Cultural methods. — Rice is sometimes broadcasted, but better results are gained by drilling, as the seeds are more uniformly covered and a better stand is likely to result. From one to two bushels of seed is the average quantity sown. In the United States the planting is done any time from the middle of April to the middle of May.

Irrigation is an important factor in rice-growing. Water must be plentiful and conditions such that it can be supplied and removed at will. Thus areas with just enough slope to cause the water to drain away are desirable. In the Southwest, unless the soil is very dry, the plants are allowed to reach a height of about eight inches, when the field is flooded to a depth of three to six inches. If the soil is very dry at planting time, it is irrigated enough to provide for the germination of the seed. After the plants are about eight inches high, water is kept on the field until the rice reaches the dough stage. The water must not become stagnant during the growing season, and this is prevented by maintaining a continuous flow, letting water into the field at a high place and removing at a low place. When the plants have reached the dough stage, the irrigating is stopped and the land allowed to dry enough to bear the weight of the farming implements. The grain is then cut and shocked. Later it is threshed from the shock and the rough rice taken to the mills where it is polished.

In the Southeast the water is turned into the field as soon as the seed has been sown and the soil is kept wet for four to six days. The water is then removed. In a few days the area is again flooded and kept wet for about three weeks or a month, when the irrigation is stopped and the fields hoed. When the jointing of the plants begins, the fields are again hoed and flooded, the water being allowed to remain on the ground until about a week before the harvest.

Upland strains of rice are grown without irrigation. The seed is planted in rows from two and one-half to three feet apart and the plants are given several cultivations and one or two hoeings during the season.

BUCKWHEAT

92. Distribution and characteristics of buckwheat. — Buckwheat belongs to the dock family and, although not a cereal, has for many years been cultivated like them, and for this reason is generally described in connection with wheat, oats, and rye. The flowers are white, tinged with pink. The seeds are three-sided and resemble those of the dock. The plants start to bloom about four weeks after planting and continue blooming until killed by frost. Thus at harvest time the plants contain both flowers and mature seeds.

New York and Pennsylvania produce about two-thirds of the buckwheat grown in the United States. The average production for the whole country is about 15,000,000 bushels; of this, New York produces about 6,000,000 bushels and Pennsylvania 4,000,000. Michigan, Maine, West Virginia, and Virginia are next in production, in the order named.

The chief use of buckwheat is for flour for making griddle cakes. The grain is sometimes fed to live-stock, especially poultry. Buckwheat middlings and bran, by-products from the manufacture of buckwheat flour, are used as cattle feed. Buckwheat is often planted by bee-keepers, the flowers being a source of nectar for the bees.

93. Cultural methods. — A crop of buckwheat will mature in about eight to ten weeks after planting. Being a short-season crop, it is often planted on ground that cannot be made ready for some other stand, or where other crops have been planted and failed. It will grow on many types of soil and will do fairly well on poor soil. For this reason, it is often grown on soil that will not produce other crops profitably. The type best suited to buckwheat, however, is a well drained, fairly moist sandy loam that is not excessively rich; if the soil is too rich the grain will lodge badly. For the best results, the land should be plowed long enough before seeding to give the soil time to settle and the sods and other organic matter time to start to decay. The land should then be prepared as for cereal crops and a mellow seed-bed secured.

The acre-rate of seeding varies from two to five pecks. The seed may be broadcasted or drilled; drilling requires about a peck less seed to the acre and a more uniform stand is likely to result.

The crop should be cut soon after the first seeds mature and before the first heavy frost. If the cutting is delayed, much grain is likely to be lost by shattering. The implements generally used for cutting buckwheat are either the reaper or the binder with the bundle-tying part removed. On small areas much of the grain is cut with the cradle. The grain is allowed to dry in the swath for a few days and is then bound loosely by hand in bundles that are set up in small shocks and allowed to cure. Either a cloudy day or the early morning hours is the best time to cut and shock buckwheat; handling it while the grain is somewhat moist prevents excessive shattering. The crop is threshed by means of a regular threshing machine.

QUESTIONS

1. Why is winter wheat seeding often delayed until after the first frost?
2. What are the advantages of seeding wheat with a grain-drill over broadcasting it?

3. How are the following weeds combated in wheat fields: chess, darnel, cockle, wild garlic, pigeon-weed, wild mustard?

4. Describe both the hot water and the formalin methods of treating smuts of wheat. Which treatment is used for loose smut? Which one for stinking smut?

5. Describe the grain-bearing portions of the cereals.

6. What kind of oats should be planted in the South? Why?

7. Why is rye cut green when the straw is to be sold for manufacturing purposes?

8. Explain the difference between two-rowed and six-rowed barley.

9. Describe the method of irrigating the rice land in Louisiana. In South Carolina.

10. What are some of the advantages of buckwheat as a crop? How is buckwheat harvested?

EXERCISES

1. **Bushel weight of grain.** — Fill a peck measure level full of wheat and compute the weight of a bushel. Do the same with the other small grains. How do these weights compare with the published weights of these grains? The legal weights and measures are generally published in the U. S. Department of Agriculture Yearbook.

2. **Testing seeds of grain.** — Sprout one hundred seeds of each of the small grains in seed testers and determine the percentage of germination. Do this with several samples from different sources. Study the sprouted seeds and find the caulicle and the plumule. How do the seeds like wheat and rye that are free when threshed differ in sprouting from barley and oats?

3. **Smut of grains.** — In a wheat or an oat field place a hoop or rectangular frame over a section of the growing grain, count the plants, and if any are smutted, determine the percentage. Secure wheat and oats from farmers and in the school laboratory practice the two methods of smut treatment with wheat and the formalin treatment with oats.

4. **Examination of grain heads.** — Secure mature heads of all of the different kinds of grain grown in the vicinity and when dry mount them on cardboard by pasting narrow strips of paper across the stems. During the school year examine each kind of grain carefully and study the botanical characters as previously given. Make drawings of each of the small grains.

5. **Tillering of grain plants.** — In a field of small grain study the tillering of the plants. Notice that several plants grow from a seed. Com-

pare the number of stalks on a plant growing far separated from other plants and one growing in a thickly planted field. Also, make comparisons of plants growing in light and in heavy soils. How do you account for the differences?

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CHAPTER VIII

GRASSES AND SORGHUMS

Grasses

Characteristics of grasses.
Number of grasses cultivated for hay and pasture.
Uses of grasses.
Soils for grasses.
Purchasing and planting grass seed.
Harvesting grass crops for hay.
Grasses for hay and pasture.
- Timothy.
- Kentucky blue-grass.
- Canada blue-grass.
- Redtop.
- Orchard-grass.
- Rye-grasses.
- Meadow-fescue.
- Tall oat-grass.
- Brome-grass.
- Bermuda-grass.
- Millets.

Sorghums

Description of sorghums.
Broom-corn.
- Groups.
- Cultural methods.

Saccharine sorghums.
- Groups.
- Cultural methods.

Non-saccharine sorghums.
- Groups.
- Cultural methods.

GRASS is the fundamental crop in North American husbandry. It provides the base on which the great live-stock industry is developed. Grass holds and protects the land, and its extensive

root system contributes much to the structure and amelioration of the soil. One hardly thinks of a farm without forage and grazing. Most of the hay and pasture crops are perennial grasses, but in California and other parts the annual grains, as oats, may be grown and cured for hay. Many parts of the country have good native pasture grasses. This is true of the western plains. The South has few native grasses of the hay and pasture type, but the introduced species supply the need. In the Northeast, timothy grass, an introduction from the Old World, is the most important single species. All the true cereal grains belong to the grass family. Sorghum yields much forage, as well as sirup and grain. The products of agriculture are of two great classes, the crops and the animals; horses, cattle, beef, swine, poultry, subsist largely on the grasses and the grass-family grains.

GRASSES

94. Characteristics of grasses. — The term "grass" is somewhat misleading. Botanically it means a member of a particular group of plants known as the grass family. In common usage it is often applied to any plant that is cut for hay, including legumes like clover and alfalfa, as well as certain sedge-like plants often found growing wild. Corn, wheat, oats, barley, and rye are members of the grass family. As a rule they are grown for the grain and straw, but are often cut for hay. Some of the common characteristics of grasses are: (1) They have a fibrous root system; a comparison of the roots of wheat and clover will show the numerous thread-like roots of the one and the long tap-root of the other. (2) The stem, or culm, has a smooth wall and may be hollow except at the nodes or may be filled with pith; the culm of most varieties of wheat is hollow, that of corn is filled with pith. (3) The leaves are parallel-veined, differing from the netted-veined leaves of many plants. (4) The leaves are made up of three parts, the sheath, blade, and ligule; the sheath starts from a node and

envelops part of the internode; the blade continues from the sheath and is the most apparent part of the leaf; the ligule is at the upper part of the sheath where it joins the blade and it varies in size considerably in the different species. (5) The blossoms are formed in a head which varies materially in different species as, for example, the head of wheat and oats, or of corn and timothy.

95. Number of grasses cultivated for hay and pasture. — According to Montgomery some fourteen hundred species of grass are found in the United States and about five thousand in the world. Of this large number, however, only a few are cultivated extensively in the United States for hay and pasture and a few others are of local importance in certain areas. There are reasons why so few of the many grasses are planted. A grass must produce seed that can be easily and cheaply harvested and it must be productive and persistent. Most of the natural wild grasses fail in one or more of these respects. The grasses commonly cultivated in America are described on subsequent pages.

96. Uses of grasses. — The grasses that are planted principally for hay and pasture are of great economic value to farmers. In some sections hay is the chief crop. Hay cured properly is a palatable feed for live-stock and it will keep for a long time, thus extending the period during which the grass can be fed. The use of grass as pasture is important. In some sections, especially where land is cheap or of such nature that it is not easily tilled, the cheapest way to keep cattle, sheep, and horses during the summer is to let them run on pasture.

Grasses, also, are used extensively for lawns. The fine leaves and creeping habits of some varieties make them especially useful for this purpose. Kentucky blue-grass, where it will grow, is one of the best grasses for lawns. Bermuda-grass is much used for lawns in the South.

97. Soils for grasses. — The type of soil considered to be best for grass is a fertile clay loam. The fibrous root system

seems better able to derive plant-food from finely divided than from coarse soil. Soils for grasses should be well drained for best results, but some varieties of grass can be made to grow on soil that is too wet for other crops and some kinds will grow on dry soils. Thus it is seen that grasses have a rather wide adaptability as to soil.

The land to be seeded to grass should be well prepared. Usually the crop is harvested for several years and for this reason, especially, it pays to give the land good preparation before seeding it. The plowing should be deep and the surface preparation thorough.

98. Purchasing and planting grass seed. — Much grass seed of poor quality is on the market, but usually good seed can be obtained from a reliable dealer by paying a reasonable price. It does not pay to plant the inferior quality. Weed seeds, as a rule, are less common in grass seeds than they are in clover and alfalfa seed, since they can be removed easily from the former by means of fanning mills. Nevertheless much of the seed offered for sale contains too high a percentage of weed seeds. Often an examination with a hand lens will reveal their presence. Such a product should, of course, be avoided.

When grass is to be grown alone in a field the seed is usually broadcasted either by hand or by means of broadcast seeders, of which there are many good types on the market. When grass and a grain are to grow together the seeds of both are usually planted at one operation with a grain drill.

99. Harvesting grass crops for hay. — To secure the best results, grass for hay must be harvested at the proper stage of growth. If allowed to become too ripe, the hay is woody and not relished by live-stock; if too green, the grass will be difficult to cure and the yield of hay will be small.

Modern hay-making machinery has been highly developed and much of the labor is carried on by horse or mechanical power. The grass is cut with a mower (Fig. 56) and allowed

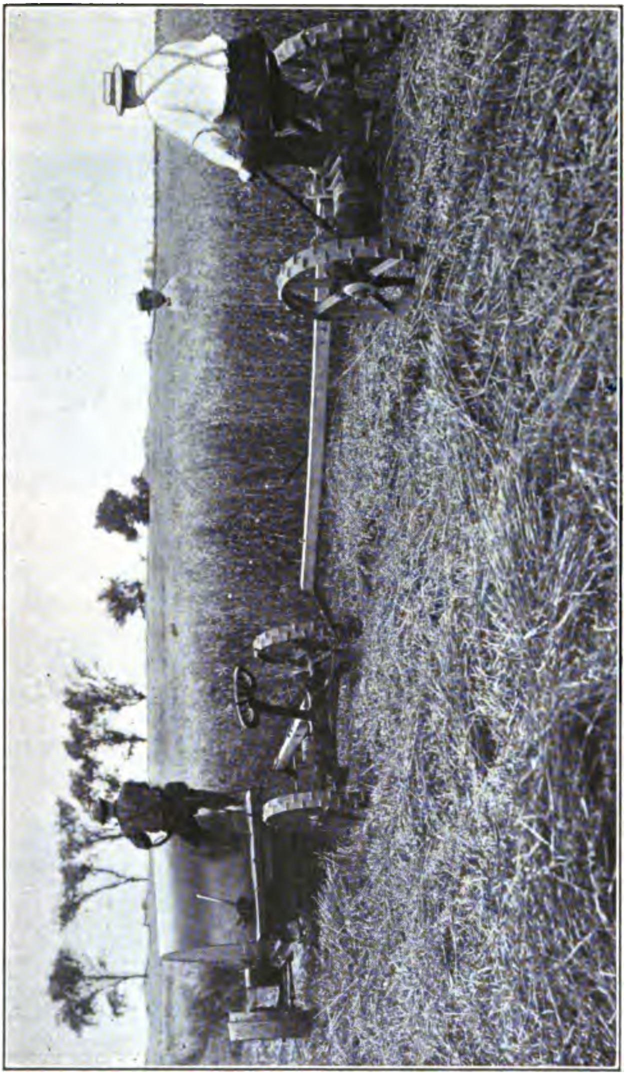

Fig. 56. — Mowers in a hay field

to lie in the swath for a time to cure; if the sun is shining a few hours will generally be enough to cure the hay sufficiently. In case the hay becomes wet or a very heavy crop has been cut, the use of a hay-tedder may be necessary. This implement

FIG. 57. — A hay field. The hay is bunched in cocks.

is provided with long, forked arms that turn, or kick the hay over, as the implement is drawn across the field. After the hay has cured, it is raked into windrows, usually with a hay rake, of which there are several types on the market. From the windrows it is either placed in cocks (Fig. 57) or hauled

FIG. 58. — Loading hay by hand.

FIG. 59. — Loading hay with a hay loader.

direct to the stack, barn, or shed. For transporting the hay, a rack placed on the running gear of a wagon is usually employed. These racks may be loaded by hand as shown in Fig. 58, or with a hay-loader, as shown in Fig. 59. A sweep-rake (Fig. 60) is sometimes used to convey the hay from the wind-

FIG. 60. — A sweep-rake bringing the hay to the stacker.

row, cock, or swath and transport it to the stacker (Fig. 61), a device used to build the stack. Several types of stackers are on the market and the use of any of them means labor saved. If the hay is to be placed in a mow or shed, hay forks, hay

FIG. 61. — Stacking hay.

slings, or carriers are often employed to do away with the hand labor of pitching the hay.

100. Grasses for hay and pasture. — The grasses that are extensively cultivated for hay and pasture are timothy, Kentucky blue-grass, rye-grasses, redtop, and orchard-grass. Those of secondary importance are meadow-fescue, tall oat-grass, Bermuda-grass, and Canada blue-grass. All of these are briefly described on the next few pages.

Timothy. — Considerably more than half the area devoted to grass in the United States is planted to timothy or some mixture containing timothy. Often it is planted with red

clover. The chief timothy-producing region lies north of the Ohio River and east of the Missouri River. The grass is also grown in the northern part of the Pacific Coast States. It is not well adapted to the South, being easily killed in summer, In money value timothy leads all other grasses grown for hay.

FIG. 62. — Timothy.

Timothy is named from Timothy Hanson of Maryland who, it is said, introduced the grass from England about 1720. It is recorded that a man by the name of John Herd was cultivating the grass in New Hampshire about 1747 and in New England and some other sections it was long known as Herd's grass. The common name now in most sections is timothy, although in parts of New England the name Herd's grass still persists. This is unfortunate, because this name is used in some sections for redtop.

FIG. 63. — Kentucky blue-grass.

Timothy (Fig. 62) is an erect-growing plant with an average height of two to four feet. The head is a spike from three to four inches long. The leaves are not abundant and usually grow near the base of the plant. New stems are produced by tillering and also by means of short stolons; often a single plant in a few years will produce a clump a foot or so in diameter. Two or three crops of timothy are generally produced before the ground is broken up and under very favorable conditions fields have been kept in timothy for eight to ten years or even longer.

Kentucky blue-grass. — The most used pasture and lawn grass is Kentucky blue-grass, or June-grass as it is sometimes

called (Fig. 63). It is cultivated chiefly in the timothy region and in the states just south of this section. In the South it is usually killed in hot weather, but will endure in shady places. It is not a good hay plant, but as a pasture and lawn grass it has no equal. It makes a dense, firm sod that improves with age and it stands pasturing well.

Fig. 64. — Canada blue-grass.

Canada blue-grass. — Characteristic differences between Canada blue-grass (Fig. 64) and Kentucky blue-grass are that the former has somewhat flatter stems, a less open head, and a bend in the stem. It has been found particularly well suited to conditions in the southern part of Canada and the northeastern part of the United States. On the whole it is less productive than Kentucky blue-grass, but on some soils, especially those that are acid or sandy, it will make a better growth. It makes a good pasture, but does not start so early in the spring or grow so rapidly as Kentucky blue-grass.

Fig. 65. — Redtop.

Redtop. — The grass redtop (Fig. 65) is widely distributed. It grows best in a rather cool climate, but it also thrives in a warm climate and can be grown in the South. It is not as good a hay plant as timothy, but it stands wet and acid soils better and in the timothy region is often used on such soils in preference to timothy. Its principal merit is that it often will grow

where timothy fails. As a pasture grass it ranks next to the blue-grasses.

Orchard-grass. — The plants of orchard-grass (Fig. 66) grow well in the shade and, because of this, are often sown in orchards. They grow in bunches and make an uneven sod. The grass does well in the southern part of the timothy section and is also grown successfully about three hundred miles farther south. West Virginia, Virginia, Kentucky, Missouri produce most of the crop. It will grow on most kinds of soil and will endure wet ground, but makes its best growth on well drained, fertile land. As a hay plant it is much less desirable than timothy and its culture becomes really important only outside of the timothy region. As a pasture grass it ranks with timothy; live-stock eat it readily and it starts growth early in the spring and continues late in the fall.

FIG. 66. — Orchard-grass.

Rye-grasses. — The rye-grasses are cultivated extensively in Europe, but not much in America. There are two kinds, the Italian and the English, or perennial. Italian rye-grass (Fig. 67) is a short-lived perennial; often it lasts only one year. In the Pacific Coast States it is sometimes grown in meadows and has been recommended for the South as a soiling crop. English rye-grass is adapted to both pastures and meadows and is one of the chief grasses of Europe. It is a perennial that grows best on moist, fertile soils. It makes a good quality of hay and is grown to a limited extent in the Pacific Coast States.

FIG. 67. — Italian rye-grass.

Meadow-fescue. — Like the rye-grasses meadow-fescue (Fig. 68) is grown extensively in Europe, but not much in America. The chief sections in the United States where it is found are western Missouri and northeastern Kansas. The quality of hay is not so good as that from timothy, but the yield is about the same.

Fig. 68. — Meadow-fescue.

Tall oat-grass. — This oat-grass (Fig. 69) is a native of Europe where it is much used for meadows and pastures. In the South this grass remains green all winter and for this reason the name evergreen-grass is often applied to it. It seems well adapted to the South and will grow on soils too sandy for other grasses.

Brome-grass. — The drought-resistant plant, brome-grass (Fig. 70), is adapted climatically to North Dakota and to the west and northwest of that state. It makes palatable pasture and good hay. A field is usually cut for hay for about two seasons, after which it is turned into pasture. It will not, as a rule, produce more than two good crops of hay, but will make excellent pasture for several years. It is a very valuable grass in the regions where grown and supplies a great need in that territory.

Fig. 69. — Tall oat-grass.

Bermuda-grass. — In the South, Bermuda-grass (Fig. 71) is grown extensively. It has a creeping habit and is much used as a pasture and lawn grass and to some extent for hay. When intended for hay, two or three cuttings are made in a season and the total yield does not usually make more than a ton and a half to the acre. It is very persistent and very difficult to eradicate when once established and, for this reason, it is looked on with disfavor by many.

Millets. — Several annual grasses are used for forage, the chief ones being the millets. The term millet includes a number of species. The ones most commonly grown in America are the foxtail millets, the broom-corn millets, and the barnyard millets.

Fig. 70. — Brome-grass.

The foxtail millets resemble the foxtail weed. The three important varieties are common millet, German millet, and Hungarian millet. Common millet is the smallest and matures earliest. It is adapted to northern sections. Under favorable conditions it will yield two to two and one-half tons of hay to the acre. German millet is the largest variety and requires a somewhat longer season for development than either of the others. It is popular in the Central States and the South where it gives larger yields, but coarser hay than either of the other two foxtail millets. Hungarian millet is intermediate in size between the other two varieties and requires a longer season than common millet. It is popular in the Eastern States. Its yields are somewhat heavier than common millet, but the hay is likely to be of a poorer quality.

Fig. 71. — Bermuda-grass.

The broom-corn millets have the head spreading in a panicle somewhat like the head of broom-corn. (See Fig. 72.) They mature earlier than the foxtail millets and are adapted for culture chiefly in the North Central States.

The barnyard millets are varieties of the common weed, barnyard grass. A cultivated species known as Japanese

Fig. 72. — Head of broom-corn.

millet is grown to a limited extent in the United States. The hay is coarse and of poor quality.

The millets are quick-maturing crops and, in addition to being used for hay, are often planted for soiling crops and sometimes for pasture. They should be planted after the ground is warm, usually after corn-planting time. The seeds are small and the soil should be made into a fine seed-bed.

SORGHUMS

101. Description. — Three distinct classes of sorghums are grown in the United States, (1) the broom-corns, (2) the saccharine, or sweet sorghums, (3) the non-saccharine, or grain sorghums. All of the classes have certain common characteristics. The plants are annuals belonging to the grass family; they have a strong, fibrous root system; they withstand drought remarkably well; the stems are tall, varying in different varieties from four or five feet to twelve feet; the leaves are long, narrow and more pointed than those of corn; the head varies in shape from a spike-like panicle in the grain sorghums to a long branched panicle in the broom-corns; the grains are round, much smaller than those of corn, and are usually either red or white in color.

102. Broom-corn. — This corn has straight stems and long, straight, loose, open heads that are used in the making of brooms. The stalks are dry and pithy and lack the sweet juice of the saccharine sorghums. The seed heads (Fig. 72) are known as the brush.

Groups. — Two groups of broom-corn are under cultivation, the dwarf and the standard. The dwarf grows from four to six feet high, has a large quantity of foliage, and produces a fine brush from ten to twenty-four inches long. It is usually made into whisk-brooms, although some of the larger heads are made into carpet brooms. The standard broom-corn grows to a height of ten to fifteen feet and has a brush from eighteen to twenty-eight inches long. It is used for the making of carpet, stable, and warehouse brooms.

Cultural methods. — Broom-corn requires a climatic condition similar to that for corn. Most of the commercial crop is grown in Illinois, Missouri, Kansas, and Oklahoma, Illinois being the chief producer.

Dwarf varieties are planted in rows usually three feet apart with the plants two to three inches apart in the rows; and standard varieties in rows from three and one-half to four feet apart with the plants three inches apart. The date of planting is a little later than that for corn; the ground must be thoroughly warmed before the seeds are sown. Corn-planters with small-hole drill plates are usually employed in planting the seed. The soil is cultivated as for corn. When the flowers are in full bloom the crop is harvested. In the operation of harvesting, the plants are either cut or pulled, the heads taken off and sorted, the immature seeds removed by means of a combing device or a thresher, and the brush cured and baled, in which form it is placed on the market.

103. Saccharine sorghums. — These sorghums are grown for the production of sirup and for forage. They have tall, leafy stems that are full of sweet juice. This juice, when extracted and boiled, makes the familiar sorghum sirup of commerce. Sorghum for forage is grown for pasture, soiling, and silage.

Groups. — Of the sweet sorghums many varieties are under cultivation, but they can all be arranged into four groups, known as amber, orange, sumac or redtop, and gooseneck.

The amber sorghums (Fig. 73) have loose open panicles usually black in color, and the seeds are reddish yellow, but are nearly covered with black, shiny glumes. The varieties of this group are the earliest maturing of the sweet sorghums and are used extensively for forage in northern sections.

Fig. 73. — Amber sorghum.

The orange sorghums have a rather compact head and the reddish-yellow seeds project from the glumes farther than in the amber varieties, thus making the heads of a lighter-red color. The plants mature about two weeks later than the amber sorghums. (Fig. 74.)

The sumac, or redtop, sorghums have small red seeds that project beyond the glumes and give the head a red appearance. They mature about the same time as the orange varieties.

Fig. 74. — Orange sorghum.

In the gooseneck sorghums the head is borne in a curved stem that bends downward. The heads at maturity are almost black in color and the plants mature about a week or ten days later than those of the orange or sumac varieties.

Cultural methods. — When sorghum is grown for sirup, the seeds are usually planted in rows three or three and one-half feet apart and from four to six inches apart in the rows. When grown for forage the method of sowing will vary with the purpose for which it is to be used. It may be broadcasted, drilled in

with a grain drill with all the holes open, or with some of the holes closed to make the rows wide enough apart to permit of cultivation between them, or with a corn-planter. In favorable seasons the heaviest yield of hay and best quality forage are usually secured from broadcasting or drilling in close rows. The crop for hay may be cut with a mower, a binder, or a scythe. When grown for silage, the seeds are planted in wide rows and the plants are usually cut with a corn-harvester. As a soiling crop, sorghum is more easily handled when sown in a wide row than in close planting. For pasture, it should be sown or drilled thickly. Sorghum is best cut for hay or soiling purposes from the time of heading until the seeds are in the dough stage. For sirup the harvesting is done when the seeds are in the late-milk stage. The heads and leaves are removed before the juice is pressed from the stalks, which is done by passing the stalks between heavy rollers, after which the juice is evaporated to the desired consistency.

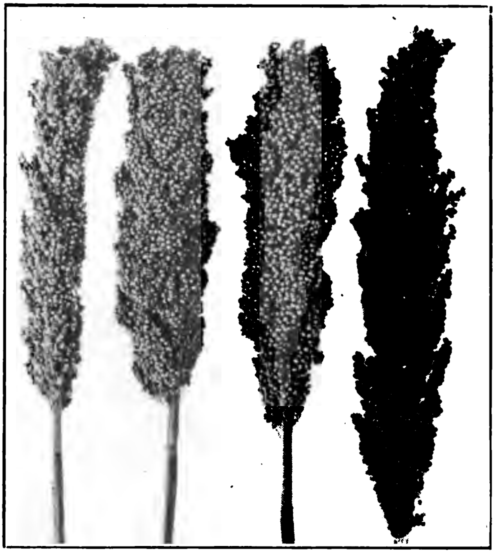

Fig. 75. — Heads of four varieties of kafir.

104. Non-saccharine sorghums. — These sorghums are grown chiefly for the grain, which is contained in the matured heads. The forage value of the stems is not large, except in the kafirs, which have semi-juicy stems with large and abundant

N

leaves. These grain sorghums are grown chiefly in Kansas, Oklahoma, Texas, New Mexico, and Colorado. They are drought-resistant plants and make very valuable crops in sections too dry for corn. Compared with corn they are somewhat higher in protein, the carbohydrate content is about the same, and the fat much lower. In feeding value they have been found to be about 90 per cent that of corn. They are palatable and are eaten with relish by live-stock.

Groups. — The chief groups of the non-saccharine sorghums are kafir (Fig. 75), milo, durra, and kaoliang. The groups differ in shape and size of the heads and in size of the stem and stalks. All have the same use.

Cultural methods. — The crop is seeded and cultivated much like corn. It is harvested in four ways — by cutting with a corn-binder, by heading with a kafir-header, or with an ordinary grain-header, or by heading by hand. That cut with a corn-binder is usually shocked and either headed later or fed in the bundle. Proper curing and storage is a problem in handling the headed grain. If the crop is at all green or is wet from rains, the heads are usually thrown out in long, shallow piles to cure, after which they are stored in cribs or granaries. If the crop is fully mature and dry, the heads may be taken to the storage place without spreading in piles. Cribs and bins used for the storage of the heads must be well ventilated or the grain will heat too much.

QUESTIONS

1. What is a grass from the botanical standpoint?
2. State the chief uses of grasses.
3. Why should not cheap grass seed be planted?
4. What is meant by the curing of grass?
5. Which grass grown for hay is of the greatest value in the United States?
6. What is the chief grass used for hay in the region where you live? How is this hay disposed of by the farmers? Is it utilized as feed for live-stock on their own farms or is it sold to be shipped from the

region? Which method is better from a soil-improvement standpoint?

7. Tell how the following grasses multiply after planting: timothy, Bermuda-grass, blue-grass.

8. What are the chief annual grasses used for hay?

9. State the characteristics of the sorghums.

10. For what two purposes are saccharine sorghums grown?

11. In what part of the United States are the grain sorghums grown? How does the grain of these plants compare with that of corn in feeding value?

EXERCISES

1. **Roots of grasses.** — Dig up a few plants of timothy or other grass and wash the soil from the roots. How deep did the roots go into the soil? What term is employed to describe the root system of grasses? Dig up a few clover or alfalfa plants and compare with the grass plants. How do the two classes differ in length and arrangement of the roots?

2. **Tillering of grasses.** — Examine grass plants in the field for tillering in the way small grains were examined. Which kinds tiller and which do not?

3. **Testing of seeds for germination.** — Secure from several sources samples of grass seeds and test them for germinating properties in seed testers.

4. **Purity of seeds.** — Examine the samples of grass seed with a hand lens to determine whether or not weed seeds are present. Secure from the Secretary of Agriculture, Washington, D. C., a copy of Farmers' Bulletin 382 and by following the directions given in this bulletin determine the purity of the samples.

5. **Characteristics of different grasses.** — Throughout the year as the different grasses mature secure plants showing roots, stems, and blossoms. Press and mount them on cardboard. When studying grasses in the laboratory observe their characteristics by examining these mounted specimens. Write descriptions and make drawings of the plants.

6. **Collection of seed.** — The seeds of the chief grasses and the weed seed commonly found with the grass seed should be available for study in every school-room where secondary agriculture is taught, and these collections should be made by the pupils. To care for such samples properly some kind of a case is necessary in which to store the seeds. The following description of a seed case from Department Bulletin 527 prepared by the author for the United States Department of Agricul-

ture will enable a pupil who is handy with tools to make a case for use in the school-room:

"Figure 76 shows a convenient case in which small bottles of seeds may be stored. The bottles are straight sided, ½ inch in diameter and 2½ inches deep; they can be purchased at drug stores for about 10 cents a dozen. The material required for making the case is a piece of white

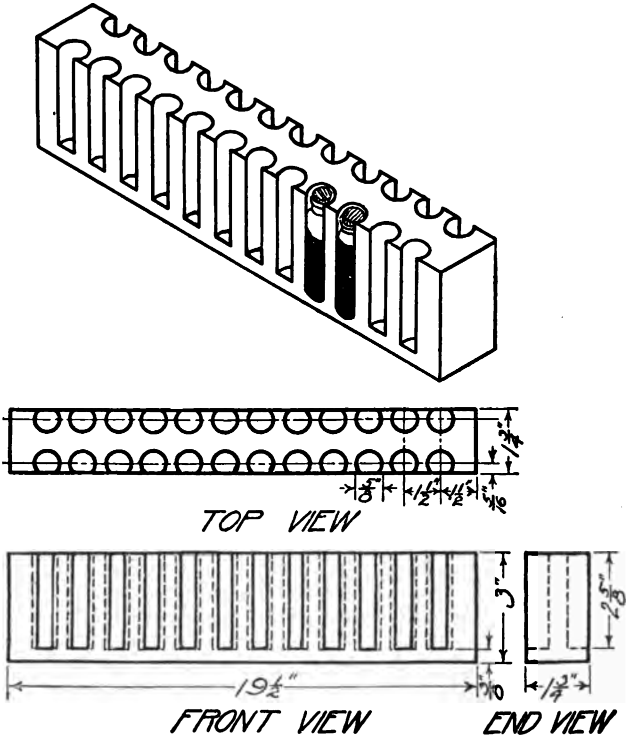

Fig. 76. — Case for storing bottles of seeds.

pine 2 inches by 4 inches by 20 inches. Finish the piece to the dimensions shown in the drawing, 1¾ by 3 by 19½ inches. Gauge two lines $\frac{5}{16}$ inch from both sides on one edge. On these gauge lines lay off centers for holes 1½ inches apart, beginning 1½ inches from one end. Place the piece, with a strip of scrap board against it on one side, in a vise, and with a ⅝ inch bit and brace bore holes 2⅝ inches deep on the

centers that have been laid off. The scrap board prevents the lumber from slivering. Bore the holes straight into the wood. To aid in boring the holes to the exact depth desired, bore a $\frac{5}{8}$ inch hole lengthwise through a piece of scrap lumber $1\frac{1}{2}$ by $1\frac{1}{2}$ by 4 inches, and slip this on the shank of the bit to form a collar; the bit should extend $2\frac{5}{8}$ inches beyond the collar. Bore a trial hole in a piece of scrap lumber with this collar on the bit; if the hole is too shallow, cut off the end of the collar to get the correct length; if the hole is too deep, make another collar. After the holes are bored, trim the edges along the side of the piece until each opening is $\frac{3}{8}$ inch wide. Bore and trim up the holes on the other side of the piece in the same manner. Paint or stain the case; this will improve its appearance as well as preserve the wood."

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CHAPTER IX

LEGUMES

Description of legumes.
Uses of legumes.
Legumes for forage.
Red clover, alsike clover, crimson clover, white clover, alfalfa, bur clovers, cowpeas, soybeans, field peas, vetches, Japan clover, peanuts.

WHEN studying soils we learned the great value of legumes for soil improvement by reason of the nitrogen that is converted into an available form by the bacteria on the roots. As hay and pasture plants, also, the legumes rank high and when grown with grasses, especially in pastures, the mixture makes a feed much relished by live-stock, and the food value is high. Many of the leguminous crops yield important human food, as lentils and the different kinds of beans and peas. The value of legumes both from the soil-improvement and the crop-producing standpoint is indeed very high and farmers could ill afford to do without them. The rôle of the legumes in nitrogen-gathering is one of the most fascinating of modern contributions to agriculture.

105. Description. — The legumes, or pulse plants, are among the most useful of the cultivated plants. There are some ten thousand species, varying in size from small herbs to large trees. Those of most importance to the farmer are herbaceous plants that belong to the Papilionaceæ, or pea, sub-family. This name was given because of the resemblance of the flowers to a butterfly, the Latin name of the butterfly being papilio.

The flowers are arranged differently in the various species. They may be single as in the cowpea, distributed along the

stem as in the vetches, in an umbel at the end of the branch as in the red clover, or in a spike as in the crimson clover. When arranged in an umbel or a spike, each of the single flowers has the butterfly-like appearance.

The leaves of legumes are made up of three or more leaflets carried on a stalk, or petiole. Unlike the grasses, the legumes have a tap-root, which varies in depth and in methods of branching. The fruit is a pod, or legume, and it is from the form of the fruit that the family of plants derives its name.

106. Uses of legumes. — One of the chief uses of legumes is for hay. Each section of the country has a variety that can be grown profitably for this purpose. Legumes are valuable hay plants because they are rich in protein. Hay from grasses, on the contrary, is relatively poor in protein. In forming rations for live-stock, it is often advantageous to mix the hays from the two kinds of plants in order to balance the protein-content. Often the two are seeded together.

In addition to use as hay, legumes occupy an important place as pasture plants. White clover, where it will grow, is the most valuable legume for pastures. It has the creeping habit and when once established will soon spread, occupying much of the land together with the grasses. It stands grazing well, which is an important quality in a pasture plant. Japan clover and bur clover hold much the same place in the South as a pasture plant as white clover does in the North. Red and alsike clovers are used for pasture purposes, but these plants are grown principally for hay and the fields are used for pasture after the hay has been cut. In some sections alfalfa fields after the hay has been cut are used as pasture, especially for swine.

Legumes are also used in making lawns. White clover is the chief sort for this purpose. Its seed is sown with the grass seed and the plants come up quickly, occupying much of the land the first season. In later seasons part of them disappear and the grass becomes established.

The seeds of many of the legumes are of use as human food. Beans, peas, peanuts, and some varieties of cowpeas and soybeans are the chief legumes grown for this purpose. The seeds are rich in protein.

Another very important use of legumes is as soil improvers. Legumes, whether grown for forage, seeds, or for turning under as green-manure crops, are of benefit to the soil and their great importance to permanent soil fertility must not be lost sight of by the American farmer if the fertility and productivity of the lands are to be maintained.

FIG. 77. — Red clover, the most important leguminous forage crop of the United States.

107. Legumes for forage. — Many species and varieties of legumes are under cultivation in the United States. Some grow much better in some sections than in others, but there is a variety adapted to every section. Among the chief legumes grown for forage are red clover, alsike clover, crimson clover, white clover, alfalfa, bur clover, field peas, cowpeas, soybeans, vetches, sweet clover, Japanese clover, Florida beggar-weed, velvet beans, and peanuts.

Red clover. — The most important leguminous forage crop in the United States is red clover (Fig. 77). It is easily grown, is well adapted to crop rotation, and grows well with timothy, the chief grass used for hay. It has been for a long time a stable hay crop in the northeastern part of the United States.

It grows best in the timothy section, but is also cultivated extensively as far south as Tennessee, as far north as Ontario and Quebec, Canada, and as far west as the Dakotas. It is grown to a limited extent in the Northwestern States and in certain sections of the South.

Well-drained, fertile soils of almost any type are suitable for red clover, provided they are not acid. The crop does very poorly on acid soils and liming is often necessary to secure a good stand. Frequently soils that formerly produced red clover profitably now fail to grow the crop, usually because of the need of lime.

In the North red clover seed is usually planted in the early spring. One practice is to seed the land that has been planted to grain in the fall to clover. When such fields are to be planted, the clover seed is broadcasted on the growing grain very early in the spring; often it is sown when a late snow covers the field. The soil is full of cracks at this season and the seed will sink into the ground and be covered with soil that is washed on it by the spring rains. Another practice is to sow the seed with spring grain; in this case it is seeded at the same time as the grain. Where the young clover plant can stand the winter, the seed is often fall-sown. This is practiced as far north as the central part of Pennsylvania and Ohio. The first week in August is considered to be the latest that it should be sown for Pennsylvania and Ohio conditions.

The harvesting of red clover for hay requires much care in order not to lose the leaves and blossoms. The maximum yield is secured if the plants are cut when in full bloom. When grown with timothy, it is not always possible to cut the clover at this stage. The timothy is usually about two weeks later in maturing and the clover will have lost some of its quality when the timothy is ready to cut. To avoid much loss of the leaves and blossoms, red clover or timothy containing a large proportion of red clover should be handled as little as possible when making the hay. Usually it is a good plan to put the hay

up in cocks before the leaves become very dry, as they will then dry out more slowly and will be more likely to remain on the stems.

Red clover seed often contains many weed seeds and it is necessary for farmers to examine carefully the seed that is offered for sale by dealers. The examination of a small sample with a hand lens will often reveal many weed seeds.

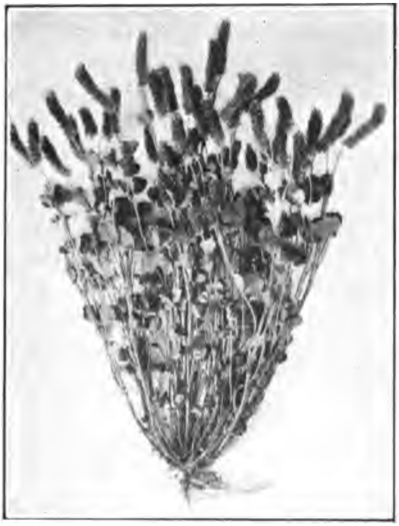

Fig. 78. — Crimson clover, an important crop in the South.

Alsike clover.—The stems of alsike clover are about as tall as those of red clover and its blossoms are about the same size and shape as white clover, but are pinkish in color. The leaves are similar to those of white clover, but are without the white crescent-shaped marks. (See the description of white clover.) Alsike clover is used for the same purposes as red clover. It grows best in a cool climate and on moist soil, but it will grow farther south and farther north than red clover and in soils too wet and too acid for the latter. Often the seed is sown in mixtures with red clover and timothy. The yield of alsike clover hay is somewhat less than that of red clover hay and as a result the latter is preferred where it will grow.

Crimson clover. — In the South an important crop for hay and green-manure is crimson clover (Fig. 78). In most varieties the blossoms are crimson or scarlet, cone-shaped, an inch or even two inches long. A variety with white blossoms is offered by seedsmen and grown to a limited extent. As usually grown,

the seed is planted in the fall and the plants harvested the next spring. The crop is grown principally from New Jersey southward. The chief use is as a green-manure crop, as described previously. Nevertheless, it is used largely as hay and when cut the plants should be harvested before the stems become too woody. The leaves and stems are covered with fine hairs and if the plants are woody before they are cut, masses of hair are likely to form in the stomach and intestines of animals that eat the hay and in some instances have been known to cause death.

Fig. 79. — Alfalfa, the chief forage crop of the West.

White clover. — Dutch, or white, clover has the creeping habit, a quality desirable in pasture and lawn plants. The blossoms are white and the leaves are marked with a white crescent-shaped mark. The plant has a wide adaption and grows wherever red or alsike clover thrives and also much farther south. In the northern part of the cotton-belt it often survives the summers.

Alfalfa. — In the western half of the United States, alfalfa (Fig. 79) is the most important forage crop. It is also cultivated to a limited extent in certain sections of the East and South, where, when soil and climatic conditions are favorable, it makes a profitable stand.

Alfalfa is a strongly branching perennial that when mature

often reaches the height of four feet. Stems branch from the crown, or top of the tap-root, and also from the lower part of the stem. The number of stems varies from three to fifteen. The roots are longer than those of any other cultivated herbaceous plant. In the West on deep soil they have been known to reach a length of thirty feet, while in the East where red clover roots would go to a depth of five feet, alfalfa roots would be

Fig. 80. — An alfalfa field.

about eight or ten feet long. The leaves are smaller than those of red clover and somewhat more pointed and the flowers are purple and arranged in rather long clusters.

In semi-arid countries alfalfa has been known to live fifty years and in the humid climate of the East and South fields will be profitable from five to eight years without replanting. Several cuttings of hay can be secured each year; in the East at least three are usually made and in the South and parts of the West five are possible. A total yearly acre-production of four to eight tons of hay is often secured. Fig. 80 shows a

field of alfalfa being cut. Notice the quantity of forage. Because of the long life of the plant and the fact that so much hay can be cut annually, farmers in the East and South often go to considerable trouble and expense in their efforts to grow the crop.

Alfalfa seems to prefer a loose, deep soil; however, good crops have been grown on fairly heavy soils. The soils must be well drained. The water-level should be at least two feet below the surface and preferably three or four feet or more. Fertility of soil is an important factor; it never pays to try to secure a stand of alfalfa on poor soil. Also, sour soils should be avoided. Like red clover, alfalfa will not make satisfactory growth on such soils and often the reason for a poor stand is that the soil was not sufficiently limed before seed planting.

Fig. 81. — Spotted bur clover.

In addition to its use as a hay, alfalfa is a valuable soiling crop. It makes so many cuttings a season that a small acreage will furnish green feed for a large number of cattle. It is used to some extent as a pasture for hogs, but not often for cattle. When pasturing a piece of alfalfa, care should be taken that it is not closely grazed, for if so the new growth may be injured. Like red clover, alfalfa seed often contain impurities and this should be kept in mind by purchasers.

Bur clovers. — Although called clovers, the bur clovers

belong to a different family and are related to alfalfa. Two kinds are grown in the United States, the spotted, or southern (Fig. 81), and the toothed, or California (Fig. 82). The spotted variety is distinguished by a purple spot in the center of each leaflet, the toothed by the edges of the leaves. The bur clovers are low-growing plants that spread out on the ground unless seeded thickly or grown with grasses. They are adapted to regions with mild, moist winters. They find their greatest usefulness in this country in the Gulf Coast States, except Florida, and along the Pacific Coast.

FIG. 82. — Toothed bur clover.

The best time for planting in the South is September, but seedings as early as August or as late as December often give fair results. Either hulled or unhulled seeds may be sown, but as the hulled seeds germinate more readily planting may be delayed about two to four weeks if this kind is used. The usual time for planting in California is the first part of October.

Bur clovers are grown for hay, for pasture, and for green-manure. When grown for hay, a dense stand is necessary to secure a crop, because of the trailing habits of the vines. Often the seed is sown with oats or wheat, as the plants then have the tendency to grow erect. For pasture purposes bur clovers are used for hogs, cattle, sheep, and poultry; horses and mules do not eat them. In the South a mixture of bur clover and Bermuda-grass is very satisfactory for pasture. Its use as green-manure is discussed in a previous chapter.

Cowpeas. — The most important legume grown in the South is the cowpea (Fig. 83). It has been cultivated for a long time in Europe, but has been of importance in the United States only for about the past hundred years. It is of tropical origin and does best in warm climates having a long growing season.

Fig. 83. — Cowpeas.

The plants are used for hay, for pasture, for green-manure, and for the seeds. The hay is about equal in value to alfalfa hay, but it is somewhat less palatable. Cowpeas do not make a very good pasture, but are sometimes used for this purpose for sheep and hogs. As a green-manure crop they are especially valuable. In the South the seeds of some of the many varieties are often harvested for human food. They make a palatable

dish and, like garden peas and garden beans, are rich in protein.

The usual ways of planting cowpeas are broadcasting, seeding in rows about thirty-six inches apart, and sowing with other seeds such as corn, sorghum, or millet. When the crop is to be turned under for green-manure the seeds are generally broadcasted. When sown with corn they may be drilled in when the corn is planted or their planting may be delayed until after the last cultivation of corn when they may be broadcasted or a row drilled in next to the corn. When sown with sorghum or millet they are broadcasted with the seeds of these plants and the whole crop harvested for hay. The mixed planting makes a hay crop easier to cure than when the cowpeas are sown alone.

Fig. 84. — Soybeans.

Soybeans. — The soybean (Fig. 84) is an erect-growing, bushy plant that reaches a height varying usually from two to three and one-half feet. These plants are valuable for forage and for green-manure and the seeds are used for human food. They are hot-weather plants like cowpeas, but can be grown about three hundred miles farther north. They do well in a humid climate, but they also have drought-resistant qualities that make them useful in regions having hot, dry summers. In

general it may be said that soybeans will prosper wherever corn can be grown profitably. When the crop is to be used for hay, the plants should be cut before the leaves are very mature; if allowed to stand too long before cutting, the leaves will drop off in curing and the stems will be woody. The soybean can be used successfully for soiling purposes; by planting several varieties that mature at different times, a succession of green crops can be obtained. The crop is sometimes pastured, but like cowpeas is not especially valuable for this purpose. In many sections, especially in the South, the seeds are ground and the oil extracted. The oil, meal, and cake are used in the same way as cotton-seed products. The methods of planting and of harvesting are similar to those followed for cowpeas.

Field peas. — With the exception of colored flowers and the seeds inclined to be yellow, field peas are much like garden peas. They are grown most successfully in regions having a cool summer and reach their best development in Canada and the northern part of United States. Wisconsin, Michigan, Pennsylvania, New York, and the high valleys of Colorado produce most of the crop in the United States. The seed is usually sown with oats. The combination is used mostly for green-manure, soiling crops, or hay, but the plants are sometimes allowed to mature and the grains harvested together.

Vetches. — The types of vetches have been described on previous pages. In addition to use as green-manure, they are sown for hay and soiling crops. When intended for hay, vetch is usually seeded with a cereal, because of the trailing habits of the plants. Seeded in the fall with rye or wheat, vetch produces an excellent soiling crop for use in the early spring.

Japan clover. — The legume known as Japan clover is an annual, usually from eight to ten inches high, sometimes under favorable conditions reaching a height of fifteen inches. It is not a clover as the name seems to indicate, but belongs to a different subclass of plants. Its chief use is for pasture in the

South, where it grows well with Bermuda-grass. A mixture of Bermuda-grass, bur clover, and Japan clover will furnish a year-round pasture. When grown on rich land, Japan clover will make a good hay crop, often yielding as high as two tons an acre.

Peanuts. — The peanut is an important farm crop in certain sections of the South. A few counties in eastern North Carolina and southeastern Virginia produce somewhat over half of the commercial crop of the United States. Peanuts are grown, however, to a limited extent in a wide range of territory in the South. The plant belongs to the pea sub-family. It bears its seed, the "nuts," underground. The flowers are borne on short stems and when the petals fade the stems elongate and turn downward; the pistil, which is pointed, passes into the soil where the ovary develops into the pod. In case the pistil fails to penetrate the soil, no fruit will be formed. The pod contains from one to four seeds. A root of a peanut plant with the stems and nuts is shown in Fig. 85. There are two general types of these nuts. One has large pods and either spreading or upright vines; the other has small pods and compact, upright vines. Virginia Runner and Virginia Bunch (Fig. 86) are large-podded varieties. The former has prostrate stems and the latter upright stems. The Spanish is a small-podded variety.

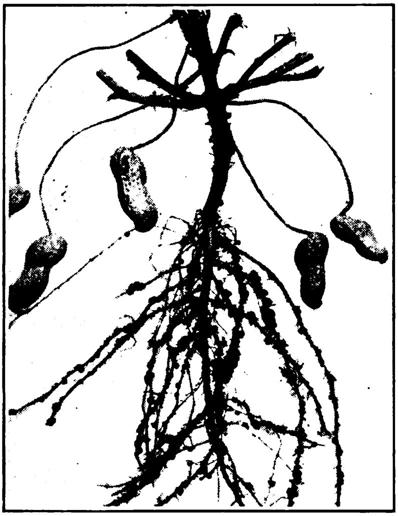

Fig. 85. — Base of peanut plant, showing the nuts.

The peanut is a valuable human food. The roasted un-

shelled nuts and the shelled salted nuts are familiar to all. Peanut-butter, a food manufactured from the kernels, has the valuable property of not becoming rancid. In foreign countries the oil is extracted from the kernels and is used as an article of commerce. It has about the same uses as cottonseed oil. The peanut cake which results from the extraction of the oil is a valuable live-stock feed. In the United States the oil industry has not been developed extensively, although the cot-

FIG. 86. — Virginia Bunch peanuts.

tonseed oil mills are now beginning to crush some of the nuts for southern farmers.

In many sections the chief use of peanuts is as a live-stock feed. Often seed are planted as a catch crop between the rows of corn at the last cultivation. The corn is husked from the standing stalks and cattle are turned into the field to forage for the leaves of corn and the peanut vines. Later hogs are turned into the fields to eat the peanuts. They will harvest them by rooting them from the ground. When peanuts are grown for market, the vines are useful as forage. Their feeding value is about equal to that of clover hay.

When grown for the nuts, a light, sandy or loamy soil is preferred. Such soils are easy to keep in good tilth, a condition necessary in order that the pistil can enter the soil easily. When grown on the red soils so prevalent in the South, the hulls are likely to be stained, which injures the market value of the nuts. If grown for stock-feeding, however, the staining of the shell is of no consequence.

The land to be planted to peanuts should not be weedy and for this reason it is well to have the crop follow a cultivated one like cotton or corn. Fertilizers are used with good results. Phosphoric acid seems to be the chief ingredient necessary and potash next. The nitrogen-content is generally rather low. The usual mixture when potash can be secured cheaply contains about 2 per cent nitrogen, 8 to 10 per cent phosphoric acid, and 6 per cent potash. From three hundred to five hundred pounds an acre is the general application. Like some other legumes, peanuts do very poorly on sour soils and in the region in which they are most grown an occasional liming is profitable.

The upright varieties are usually planted in rows thirty inches apart and the spreading varieties in rows thirty-six inches apart. In the rows the former are spaced seven or eight inches and the latter, at least twelve inches. The small-podded varieties are usually planted in the pod; the larger ones are shelled. Special planters are in use in regions where the peanut industry is extensive. About two bushels of seed an acre are required when the nuts are planted in the pods and about a half bushel when shelled nuts are planted. From one and one-half to two inches is the usual depth of planting, but this varies somewhat with the soil and the time of planting.

Peanuts should be dug before frost. September and October are the months when most of the harvesting is done. The usual method is to remove the moldboard from a plow and run this plow along each side of the row with the moldboard side next to the row. This cuts off the roots without turning a furrow. The plants are then lifted with forks or by hand and thrown

into piles. The vines are allowed to lie for a few hours in these piles and are stacked usually on the same day that they are dug. The stacks are narrow and five or six feet high and are built around a central pole which has been driven into the ground. At the base of the pole, cross sticks are nailed to keep the peanuts off the ground. The vines are piled with the nuts toward the center, space being left around the pole for

Fig. 87. — Method of stacking peanut vines.

ventilation. The stack is usually capped with a bunch of grass or hay to shed rain. Fig. 87 shows a laborer stacking peanuts.

QUESTIONS

1. Describe briefly the flowers, leaves, pods, and roots of legumes.
2. In what sections of the United States is red clover the chief legume planted for forage?
3. Why do legumes make better hay for dairy cows than grasses?
4. Why are legumes particularly valuable for green-manure?
5. State the uses of legumes other than for hay.

6. Often an application of lime is an aid in getting a good stand of red clover or alfalfa. Why is this?

7. Why are weed seeds more often found in red clover seed than in grass seed?

8. Describe the alsike clover plant and compare with red clover.

9. Why is white clover so well adapted for lawns and pastures?

10. Describe the alfalfa plant.

11. Give some of the qualities of alfalfa that make it a valuable forage plant.

12. What are the usual ways of planting cowpeas?

13. Describe the method of planting peanuts.

14. How are peanuts harvested?

15. List and describe the legumes cultivated in your section of the country.

EXERCISES

1. **Roots of legumes.** — Dig up roots of several different kinds of legumes, wash carefully, and examine for tubercules. Are they all of the same size? Describe the root system of legumes and compare it with that of grasses.

2. **Testing legume seeds for germination.** — Secure seeds of different kinds of legumes and test them for the percentage of germination as directed for grasses.

3. **Purity of legume seeds.** — Small seeds like those of alfalfa and red clover often contain many weed seeds. Examine samples carefully as directed for grasses. Learn to identify the common weed seeds usually found with the legume seeds.

4. **Experiment with red clover.** — In the red-clover region a very interesting and instructive experiment can be made by pupils to determine the advantage of liming the soil, especially if the soil is inclined to be acid. Lay off two plots of a square rod each in the school yard or on a near-by farm. Prepare the soil for planting by spading and raking it well. On one plot spread twenty-five pounds of ground limestone (how much is this an acre?). Leave the other plot untreated. Sow red clover seed on both plots and observe the results. Often but little difference will be seen until the second year.

5. **Experiment with alfalfa.** — In the East and South where alfalfa is not particularly well adapted to conditions, a plot experiment carried out as here directed will be a good indication of whether or not this crop can be grown profitably and how the land should be treated. Arrange four rod-square plots and prepare the soil carefully for planting as directed for red clover. To plot 1 apply twenty-five pounds of

ground limestone. To plot 2 apply the same quantity of limestone and inoculate the soil with alfalfa bacteria by spreading on it soil from an old alfalfa field. This should be done in the late afternoon or on a cloudy day. Why? Inoculate the soil in plot 3, but do not treat it with lime. Leave plot 4 as a check by giving it neither lime nor inoculation. Plant the seeds and observe the results of the treatment as the crop grows. Draw conclusions as to the best way to treat soil for alfalfa in your region.

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CHAPTER X

POTATOES

White Potatoes

Distribution of production.
Yields.
Climate and soils.
Fertilizing land.
Planting.
    Quantity and size of seed potatoes.
    Depth of planting.
Cultivating the potato fields.
Harvesting and storing.
Insect pests.
    Colorado potato-beetle.
    Flea-beetle.
Diseases.
    Early blight.
    Late blight.
    Potato scab.

Sweet Potatoes

Distribution and use.
Soils.
Fertilizing the land.
Cultural methods.
Harvesting and storing.
Pests of the sweet potato.
    Root-borer.
    Black-rot.

POTATOES are of two main kinds or species, — the white, Irish, or round potatoes grown in the Northern States and Canada and in the Southern States as a cool-season or early crop, and the sweet potato, grown extensively in the South. Both

of them are staple articles of food in North America, and the white potato is an article of extensive international commerce. Every day in practically every family in this country finds on the table potatoes of one kind or the other and prepared in many different ways. To grow and handle these crops is one of the primary requirements of the American farmer. The two species of potatoes require very different culture and handling, to which we may now give attention.

WHITE POTATOES

108. Distribution of production. — Europe is first in white-potato production, supplying about 90 per cent of the total crop of the world. North America comes next, with about 7 per cent. Asia, Australia, South America, and Africa follow, each with less than 1 per cent. Germany and Russia produce about half the world's crop. In the United States, according to the 1910 census, the chief producing states in the order of production are New York, Pennsylvania, Maine, Michigan, and Ohio.

109. Yields. — The average acre-yield of white potatoes in the United States is about eighty-five to ninety bushels; that of Germany is two hundred bushels and of France one hundred thirty-three bushels. The highest recorded yield in the United States is 974.8 bushels. From a comparison of these figures, it is readily seen that improvement in white-potato production in the United States is very possible.

110. Climate and soils. — The white potato does best in the cooler parts of the temperate zone. The nights should be cool, the days warm and sunshiny, and the growing season free from frost. In the United States the climatic conditions in the Northeastern States are well suited to potatoes. However, some very good yields are secured in the South.

White potatoes are grown successfully on many kinds of soils. They do best, however, on loose, well drained, fertile, sandy loams. On loose soils the crop is easy to plant, culti-

vate, and harvest, quick to mature, and the tubers are likely to be of good quality.

111. Fertilizing land. — In the East more manure and commercial fertilizer to the acre are used for white potatoes than for any other farm crop. Often as high as one thousand to two thousand pounds an acre of commercial fertilizer are applied to the soil. The fertilizer should be high in the mineral elements, but may be relatively low in nitrogen. A formula much used in the Eastern States is 3–8–10. Many growers claim, however, that this is too high in potash. During the war with Germany, with potash fertilizers so high in price and difficult to secure, growers are obliged to use much less potash than formerly; nevertheless they secure good results.

112. Planting. — The time for planting white potatoes varies with the climatic conditions, the variety, and whether early or late varieties are grown. In northern sections early varieties are planted as soon as the ground can be prepared in the spring. Late varieties are usually planted in May, although in some sections not until the middle of June. In the South for the first crop, potatoes are planted from February to April, according to conditions and the late crop, from about July 15 to August 15.

Quantity and size of seed potatoes. — The quantity of seed pieces to be planted to the acre varies with the distance apart they are placed and with the method adopted. If the crop is grown in drills about thirty inches apart and the pieces are fifteen inches apart in the row, about seventeen or eighteen bushels of seed pieces are necessary for each acre. If grown in hills about thirty-six inches apart, about twelve bushels are required.

The determination of the best size of seed piece has been the basis of many experiments and the results seem to show that a three-ounce piece will give larger yields than those of any other size. The question, also, as to whether whole or cut seed should be used is of importance. For the main crop in the

North, cut pieces are satisfactory; in the South, small whole seed potatoes seem, as a rule, to give better results. This is true in the South because the crop, if early, is planted on cold ground, and under these conditions the cut seed is likely to rot. Still, cut seed pieces are often planted with good results.

Depth of planting. — Rather deep planting, from four to six inches, is advisable under most conditions. If seed are planted

FIG. 88. — Potato-planter — a labor-saving implement.

too shallow, the tubers form near the surface and many are likely to become sunburned by exposure. Moreover deep planting usually gives better yields than shallow planting. In some sections shallow planting is practiced and, as the plants grow, the earth is ridged up over the roots and tubers. Figure 88 shows a much used type of potato-planter. Such machines are effective labor-savers and are practicable when large areas are planted.

113. Cultivating the potato fields. — Cultivation is one of the important factors in white-potato growing. If weeds appear on the ground or a crust has formed on the soil, a har-

row or a weeder should be used before the plants are above the ground, and these implements can well be employed until the vines are six inches or so high. Subsequent cultivation is usually carried on with the horse-drawn cultivators used for

FIG. 89. — Green Mountain potatoes.

corn. Implements fitted with narrow blades give good results, as they make a fine, even surface on the soil. Several cultivations are necessary throughout the season; the working of the soil should be kept up until the vines cover the ground. It is well to go over the field at least once with a hoe to kill weeds between the plants in the row.

114. Harvesting and storing. — Much of the white-potato crop is dug by hand (Fig. 89) with a potato hook or a spading fork. Horse-drawn diggers are used where large acreages are grown. Of these there are several types, ranging from a plow fitted with iron rods for the purpose of shaking the dirt from the tubers, to implements like the one shown in Fig. 90, that dig, elevate, and deposit the potatoes on the ground.

Fig. 90. — Potato-digger.

A large part of the late crop is stored for use in the winter. A storage place for potatoes should be cool, dry, and well ventilated and, as the tubers freeze easily, the temperature of the storage room should never be down to the freezing point. From 40 to 50° F. is a good range of temperature for the potato storage place. When a cellar is utilized, it should be kept dark and be provided with both an intake and an outtake for air; ventilation is an important factor in the storing of potatoes.

115. Insect pests. — The white potato is subject to two troublesome insect pests, the Colorado potato-beetle and the flea-beetle. Of these the Colorado potato-beetle does the most damage.

Colorado potato-beetle. — The familiar striped potato-bug is the Colorado potato-beetle. The female lays eggs on the leaves of the plants. Larvæ from these eggs start at once to eat the foliage and if not checked will soon strip the plant of

its leaves. The remedy is to spray the vines with a poison. Arsenate of lead paste, three pounds to fifty gallons of water, is effective or one pound of paris green to fifty gallons of water may be used, although with paris green there is some danger of burning the leaves. When the vines are sprayed with bordeaux mixture for blight, as described later, poison to kill the beetles may be added to the bordeaux, thus making one spraying answer for both the beetles and the blight.

Flea-beetle. — Small flea-like beetles are often seen on the leaves of tomatoes and white potatoes. The damage is done by the mature insect which makes holes in the leaves, thereby depriving the plant of a part of the foliage. The beetles are not readily poisoned, but they seem to be repelled by bordeaux mixture and, therefore, fields that have been sprayed with bordeaux for the blight are not usually troubled with flea-beetles.

116. Diseases. — Troublesome diseases of the white potato are early blight, late blight, and scab. These cause a large annual money loss in the United States, much of which could be prevented by timely spraying.

Early blight. — The vines in the early or middle part of the summer are subject to attack by early blight. Small brown spots appear on the leaves and later they enlarge and show rings one within another. Often the edges of the leaves die. Later in the season they turn yellow and the plants have somewhat the appearance that the vines assume when they are mature. The loss of the foliage causes the tubers to stop growing. The remedy is to spray with bordeaux mixture, but the spraying to be effective must be done before the blight has started. Growers in regions where early blight is prevalent often spray the vines before there is any sign of the disease, this being considered an insurance.

Late blight. — In leaves of plants affected with late blight, there appear dead areas usually at the margin, but often on any part. The diseased portion may be brown or nearly black and a disagreeable odor nearly always accompanies it.

Often there appears a moldy, downy growth on the surface of the leaves. This has given rise to the name, downy mildew, which is often used for the late blight. The spores of this white growth multiply rapidly and are easily scattered by the wind, which is one reason for the rapid spreading of late blight. The remedy is to spray with bordeaux mixture, and to be effective the spraying should be done early in the season before the blight starts. In New York late blight usually occurs any time after the first of August. In regions farther south it may appear earlier.

Potato scab. — The chief fungous disease that attacks the tubers is scab. The surface of a scabby potato is rough and broken. To combat the disease the seed pieces are disinfected before they are planted. This is usually done by soaking them for two hours before they are cut in a solution of one-half pint of formalin to fifteen gallons of water. Another method is to soak them for an hour and a half in a solution of bichloride of mercury made by dissolving twelve ounces in fifteen gallons of water.

SWEET POTATOES

117. Distribution and use. — Sweet potatoes are of tropical origin, and require a warm climate. The bulk of the commercial crop is grown in the South; the only state outside of that section producing any large quantity is New Jersey. The states growing large crops in the usual order of the amount of their production are Georgia, North Carolina, Alabama, Mississippi, Virginia, South Carolina, Louisiana, Texas, Tennessee, and New Jersey.

Although the sweet potato is a perennial, it is cultivated as an annual. The part used for food is the fleshy root. The plants seldom produce flowers or seeds and they are propagated, except in the case of new varieties, by division. The chief use of the roots is as human food, but they are sometimes fed to live-stock, especially hogs.

118. Soils. — A sandy or a sandy loam soil that is warm and well drained is best for sweet potatoes. On wet land the roots are likely to be coarse and of poor quality. Although often grown on heavy soils, the crop is likely to be late and not of good quality. Also, particles of the soil usually adhere to the potatoes, which detracts from their appearance. If clay soils are used, they should be well supplied with humus, as this tends to lighten them. Humus is an important factor on light soils, also, and should always be plentifully supplied.

119. Fertilizing the land. — Commercial fertilizer is profitably used for sweet potatoes. On sandy soils potassium is of chief importance and phosphorus next. A large proportion of nitrogen is not needed, as it stimulates too much vegetative growth. The general formula used contains about 1 or 2 per cent of nitrogen, 6 to 8 per cent of phosphoric acid, and 8 to 10 per cent of potash, but these percentages are often varied considerably, depending on the soil and the price of fertilizer materials.

Green-manuring is a common practice on sweet potato land, especially in the South. A crop of crimson clover turned under a few weeks before setting the plants supplies both nitrogen and humus. In New Jersey barnyard manure is often used, but in the South manure is not usually available.

120. Cultural methods. — The crop should be grown in a rotation that does not bring it on the piece of ground oftener than once in three or four years. This aids in combating a very troublesome disease called black-rot. The crop should follow a cultivated one like cotton or corn, in which has been sown a catch crop of legumes, as the cultivated crop will tend to free the land of weeds.

The depth of plowing is influenced somewhat by the kind of root demanded on the market. A short, well-rounded potato sells best and to secure this sort, rather shallow plowing is necessary. On light soils a depth of about five inches seems to give the desired result, while on heavier soils a greater depth

may be plowed without affecting the length of the potato. In the South most of the crop is planted on ridges. Experience indicates that low ridges, not over four or five inches above the water-furrow, are preferable to high ones. The ridges are generally made over a furrow in which fertilizer has been distributed. In New Jersey level cultivation is practiced.

The sweet potato slips for planting are secured by placing the roots in a layer in hot-beds or especially constructed places supplied with bottom heat. Above the layer of potatoes is placed a layer of leaf-mold or sandy soil. The roots are bedded about six weeks before the time of setting the slips in the field. When the slips are about six or seven inches long, they are removed, or drawn, as the operation is called, and transplanted to the field. Fig. 91 shows the rooted slips ready for setting in the field and Fig. 92, the beds with slips ready to pull. The bed must be watered and the slips drawn carefully. The potato is held down with one hand and the slip pulled loose with the other, the potato being left in the bed so that more slips will develop from it. Later another drawing of slips is made. To prevent the roots from drying out, the slips should be set in the field as soon as possible after they are removed from the bed. Some growers dip them in a thin mixture of clay, fresh cow manure, and water. This forms a coating over them and prevents drying out. Many growers prefer to set

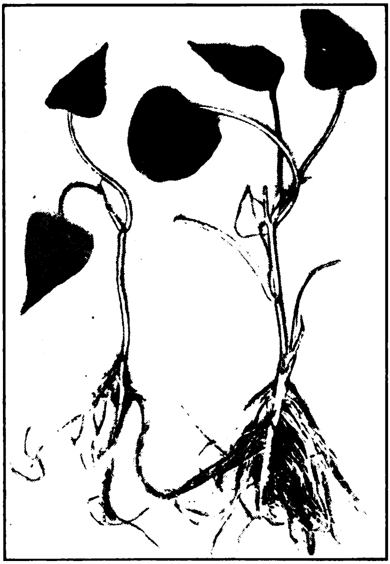

FIG. 91.—Sweet potato slips ready for setting in the field.

the slips only after a rain; others do not wait for a rain, but water the plants soon after they are set.

Preparatory to transplanting the slips, the soil is smoothed and, when hand transplanting is practiced, the rows are marked in some way in order that the plants will stand a uniform distance apart. One person then drops the plants one at a time near where they are to be planted and another follows and places them in the soil. A dibble or small trowel is often used

FIG. 92. — Sweet potato slips in hot-bed ready to pull for transplanting.

in setting the plants, but many growers, to avoid bending over and straightening up as each plant is set, make use of long-handled tongs and a lath sharpened to a flat point. In setting with the tongs and sharpened lath, the former is held in one hand and the latter in the other. Each slip in turn is picked up with the tongs, a hole is made in the ground with the sharpened stick, the slip placed in it, and the soil settled about the plant with the stick or the foot of the one doing the setting. Transplanting machines (Fig. 93) are now in common use in regions where sweet potatoes are an important crop. One of these machines sets and waters the slips as fast as a team can pull it across the field.

When grown in ridges the plants are usually set in rows three to four feet apart and eighteen inches apart in the row. When level culture is practiced, the rows are usually thirty inches apart and the plants twenty-four inches apart in the rows. In some truck-gardening regions, they are often set two feet by two feet each way.

When not enough plants are furnished by slips, vine cuttings are often made to supply the deficiency. The vines send out

FIG. 93. — Setting sweet potato slips with a transplanter.

roots from the nodes when they touch the ground. A cutting is made from the tip end of the vine, about eight or ten inches is cut off and carried to the place where it is to be set, and is planted immediately. Roots from vine cuttings are seldom troubled with black-rot and for this reason the potatoes from plants set in this way are often used for bedding the next season.

Cultivation of the sweet potato field during the growing season should be done whenever weeds appear or a crust forms on the soil. Shallow cultivation is best.

121. Harvesting and storing. — The time of harvesting depends on the demands of the market. In trucking regions,

if the price is high in late summer or early fall, the roots are often dug before the vines have finished growing. The bulk of the crop is not dug, however, until the roots are mature. A way to determine this is to examine cut surfaces on them. If a cut in a root becomes discolored, it is a sign that the root is immature; a cut on a mature root heals with a whitish covering. Most of the crop is dug about the time of the first fall frost, which is usually about four and one-half months after planting.

Before the roots are dug, the long ends of the vines must be removed. A plow with a rolling colter is often used to cut them off. The roots are then turned out with a plow. Some growers use special plows fitted with two rolling colters, one on each side of the beam. With one of these the row can be dug without first plowing to cut off the vines.

One-fifth of the sweet potato crop of the Southern States — 10,000,000 bushels of the average crop of 50,000,000 — is lost annually by decay. Careless handling at harvest time and improper storage cause almost the entire loss. Two things are essential in the storeroom — good insulation and provision for thorough ventilation.

Storage houses may be built of wood, brick, cement, or stone. Wooden houses are preferable, because they are cheaper and easier to keep dry. It is difficult to keep moisture from collecting on the walls of a cement, stone, or brick house. The house should be built on posts or piers, so as to allow a circulation of air under it. The "dugout," or a house built partly under ground, fails because it is practically impossible to keep this type of house dry, and moisture in the storage house will cause the potatoes to rot. The sills should be placed on posts or pillars twelve to fifteen inches from the ground, or just high enough so that a wagon bed will be on a level with the floor of the house.

On many farms in the South there are buildings, such as abandoned tenant houses, that could be converted into sweet

potato storage houses at very little expense. These houses will usually need to be ceiled on the inside. For this purpose two-inch by four-inch scantlings should be set against the wall and covered with building paper and then a layer of matched lumber. The windows and doors should be made tight and ventilators put in where needed.

122. Pests of the sweet potato. — Few insects are troublesome to sweet potatoes.

The *root-borer* is sometimes destructive in Texas and Louisiana. This insect bores into the roots and injures them. The treatment is to avoid storing or bedding infested roots.

Black rot is the most serious disease of the crop. Black spots appear on affected roots which soon rot. To combat this disease care should be taken not to bed infested roots and not to plant slips that show dark spots on their stems. As stated previously roots from plants propagated by vine cuttings are likely to be free from the rot and are the best kind to use for bedding. The organism of the disease is carried over in the soil and for this reason it is well to plant some crop other than sweet potatoes for a few years on land from which a badly infested crop has been harvested. Several other rots attack sweet potatoes, but the remedies are the same as for black-rot. Proper storage aids in combating the rots.

QUESTIONS

1. Compare the average yield and possible yield of white potatoes in the United States.
2. What kind of soil is best for white potatoes?
3. What size seed pieces of white potatoes seem to give best results?
4. Why is rather deep planting usually advised for white potatoes?
5. Give the life history of the Colorado potato-beetle and state the method of control for this pest.
6. How are early blight, late blight, and scab combated?
7. What kind of soil is best for sweet potatoes?
8. What general formula is employed in fertilizing land for sweet potatoes?

9. Why should sweet potatoes not follow sweet potatoes on the same piece of ground?

10. Describe the methods of propagating sweet potatoes.

11. How can you tell when a sweet potato root is mature?

EXERCISES

1. **Size of white potato seed pieces.** — Plan and carry out a plot experiment with white potatoes using seed pieces of different sizes. Also, plan one comparing whole and cut seed pieces.

2. **Treatment for scab.** — Treat seed potatoes for scab before planting them as directed in the chapter. Use both methods and compare results. Always plant a small plot with potatoes that have not been treated in order that the results of the treatment may be known. Treat quantities of the tubers for farmer patrons of the school.

3. **Spraying of white potatoes.** — In a portion of white-potato field spray an area every two weeks during the summer with bordeaux mixture and arsenate of lead and leave an equal area unsprayed. At harvest time compare results. Bordeaux mixture is made of copper sulfate, quick-lime, and water. The quantities of copper sulfate and lime to use vary somewhat according to the kind of plant to be sprayed. For white potatoes a satisfactory formula to use is:

Copper sulfate	5 lb.
Quick-lime	6 lb.
Water	50 gal.

This is known as the 5–6–50 formula.

To make fifty gallons of the bordeaux mixture, dissolve the copper sulfate in twenty-five gallons of water and in a separate vessel slake the lime and dilute it to twenty-five gallons. Pour the two solutions simultaneously through a brass wire strainer into the spray tank. The arsenate of lead, three pounds of the paste form, should be thinned with water and poured into the tank.

4. **Fertilizer experiment with white potatoes.** — In rows across a field to be planted to white potatoes try different quantities of fertilizer. For example, in one row use the kind of fertilizer being used on the field at the rate of one ton to the acre; on a second row use it at the rate of one thousand pounds to the acre; on a third row use it at the rate of five hundred pounds to the acre; leave a row without any fertilizer as a check. At harvest time compare the yields of the different rows.

5. **Propagation of sweet potatoes.** — If possible to do so arrange a hot-bed and sprout sweet potatoes as directed in the chapter. If this work cannot be done at the school-house the pupils should, if living in a region where sweet potatoes are an important crop, take part in the work on some farm in the neighborhood.

Propagate a few sweet potato plants by means of vine cuttings as directed in the chapter.

6. **Comparison of propagation of white and of sweet potatoes.** — Place both tubers of white potatoes and roots of sweet potatoes in moist sphagnum moss and keep in a warm, dark place where they will sprout, and study the origin of the sprouts of both.

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CHAPTER XI

SUGAR-CANE, COTTON, AND TOBACCO

Sugar-cane

Distribution and characteristics.
Uses.
Soils and fertilizers.
Cultural methods.
Harvesting.
Pests of sugar-cane.
    Cane-borer, root disease, red-cane.

Cotton

The cotton plant.
Types of cotton.
Uses of cotton.
Soils and fertilizers.
Rotations with cotton.
Cultural methods.
    Plowing.
    Ridging the land.
    Date of planting.
    Planting the seed.
    Cultivating the field.
Harvesting the crop.
Pests of cotton.
    Boll-weevil, boll-worm, cotton-wilt, root-rot.

Tobacco

Tobacco-growing districts.
Classes of tobacco.
Methods of securing tobacco seedlings.
Cultural methods.
Harvesting and curing.

THE three crops considered in this chapter are essentially southern, although tobacco is grown in quantity as far north as Wisconsin and Connecticut. They are " money crops,"

the product being staple and having a definite quotation in the market. The cane supplies much of the sugar (the remainder coming from sugar-beets) and its culture is a large industry in the far South. It is a tall, large-leaved grass, with a juice in the stalks that, when squeezed out and boiled to the proper consistency makes the sugar and molasses of commerce.

Cotton is the greatest crop of the South. Fields of this shrub-like plant are everywhere in the regions warm enough to grow the plants, which is from southern Virginia southward. Farm rents are paid in bales of cotton rather than in money and in every town in the cotton-belt dealers are on hand at all times to buy the product. As will be learned, the cotton fiber makes most of the thread and light cloth used by mankind. The seeds, also, are of much importance. The oil and the meal derived from the seeds are staple articles of commerce. The oil made up to the consistency of lard is fast taking the place of that commodity. It is asserted that South Carolina produces more shortening than the hog-producing state of Iowa.

Tobacco is a native of America. In some regions its value to the farmer is very large. Companies capitalized at millions of dollars control the output and the trade in the products is extremely large.

These three crops have little in common so far as culture and handling are concerned, but as they are distinctive parts of southern agriculture they may be considered together.

SUGAR-CANE

123. Distribution and characteristics. — Sugar-cane belongs to the grass family. It has a tall, jointed stem with leaves at each node and several stalks grow in a cluster from the central stalk, as shown in Fig. 94. Sugar and sirup are made from the juice of the stem. The plant is a perennial and in tropical countries crops can be cut for several years before the field needs to be replanted. However, in Louisiana

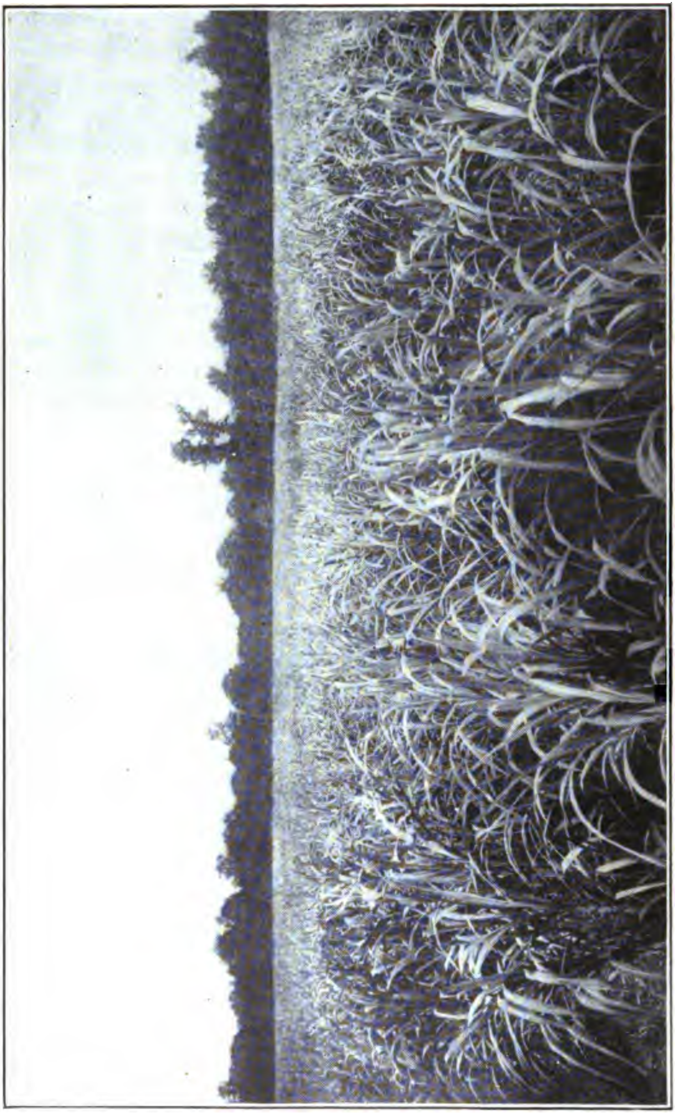

FIG. 94. — Field of sugar-cane.

and Texas, where most of the crop of the United States is grown, only two or three crops are cut before the field becomes unprofitable. In sections farther north often only one crop can be secured.

Cuba, Java, Hawaii, United States, and Porto Rico are the chief countries that produce sugar-cane.

124. Uses. — Sugar is the chief product from cane. It can be made only from fully ripened stalks, thus limiting the production to regions where early frosts do not occur. Sirup can be made from rather immature cane and in sections where early frosts do occur sirup is manufactured. This is not the same as molasses, but is made by boiling the juice of the immature cane, while molasses is a by-product of the manufacture of sugar.

In addition to the manufacture of sugar, molasses, and sirup, cane has a few other uses. The tops and green leaves are fed to live-stock; the crushed stalks are used for silage and fuel, and the making of paper.

125. Soils and fertilizers. — One of the first requirements for sugar-cane is a plentiful supply of water in the soil throughout the whole growing season. The plant with its number of broad leaves presents a large area of leaf surface from which much moisture is sent into the air by transpiration.

Soils for cane should be fertile and rich in humus. In hilly regions, well drained alluvial bottom lands are very satisfactory.

Commercial fertilizer is used profitably in growing cane. Abundant fertilizer is needed in Louisiana, because the tops and leaves of the cane are burned each year. If this material were plowed under, it would return plant-food and humus to the soil; nevertheless the burning is considered the better practice, because the fire destroys many cane-borers, a serious pest of the crop and, in addition, gets rid of much undecayed organic matter that would hamper the cultivation of the ground. Also the soil with the litter removed will dry out rapidly in

the spring, which is an especial advantage. Nitrogen is needed on most soils that are planted to cane. One way to secure this food is to use cowpeas or other legumes as green-manure every third or fourth year. Another way is to use commercial fertilizer rich in nitrogen. In Louisiana 350 pounds of nitrate of soda an acre or its equivalent in plant-food from dried blood, tankage, or cottonseed meal, has been used with good results. Phosphoric acid is also needed on most of the soils. It is generally supplied in the form of acid-phosphate at the rate of about 250 pounds an acre. Potash is not usually needed in Louisiana and Texas.

The Government recommends, as a result of experiments, the following fertilizers for the sandy pine lands as found in the southern part of Georgia:

When the cane was not preceded by a soil-improving crop:

300	pounds, nitrate of soda
100	pounds, cottonseed meal
600	pounds, high-grade acid-phosphate
100	pounds, sulfate or murate of potash
1100	pounds, total to the acre.

When the cane was preceded by a crop of velvet beans that were plowed under:

100	pounds, nitrate of soda
1100	pounds, high-grade acid-phosphate
100	pounds, murate of potash
1300	pounds, total to the acre.

In Louisiana and Texas and also in the Southeast, part of the commercial fertilizer is usually applied before the planting and a part after the plants start growth.

126. Cultural methods. — Cane in Louisiana is planted on top of beds five to seven feet wide. These beds are necessary to insure drainage. The land is plowed in the fall and the beds formed about a month later. In the growing season they are kept high and the furrows between them are kept open.

Planting starts early in the fall and continues until Novem-

ber, when men are needed to harvest the cane from other fields. Any area not planted in the fall is planted in February or March. The cane used for the later planting must have been protected during the winter by a covering of soil. A furrow shallower than the water-furrow is made in the top of each bed with a double moldboard plow. In this furrow is placed a double row of the stripped cane stalks, which are later covered with soil by means of a disc cultivator. Cane planted in the fall is covered rather deeply as a means of protection from freezing and in the spring the top part of the bed is removed with a hoe.

The methods of planting in the pine-belt east of the Mississippi differ somewhat from those in Louisiana. Beds five to six feet wide are made and commercial fertilizer placed in the water-furrow. The cane is later planted in this furrow, but before this is done a plow is run through the furrow to mix the fertilizer with the soil to prevent the eyes of the seed-cane from being injured by the fertilizer. A single row of cane is planted in the furrow and a bed formed above it. The canes are covered deep and later a part of the soil is removed. Except in parts of Florida, where fall-planting is sometimes practiced, most of the planting east of the Mississippi is done early in March.

Frequent cultivations and an occasional hoeing during the growing season up to the time the cane shades the land enough to keep down the weeds are necessary to insure a good growth. In Louisiana the water-furrow must be kept open and the bed kept at a good height to provide drainage. In the pine lands of the Southeast it is not necessary to keep the beds so high.

127. Harvesting. — In the harvesting of cane to be used for sugar or sirup, the leaves must be stripped from the stalk and the top removed. Stripping and topping are usually done when the plants are standing in the field, but in the more northern regions, where sirup is the product, the expectation of an early frost often causes the planters to have the stalks

cut before they are stripped and topped. They are piled and stripped, and topped later. After the leaves and tops are stripped, the canes are hauled to the mills and their juice made into sugar or sirup.

128. Pests of sugar-cane. — Only a few insects and diseases attack the sugar-cane.

Cane-borer. — The chief insect enemy of sugar-cane in Louisiana is the cane-borer. This borer is the larva of a moth and injures the cane by boring into it. The remedy is to burn the tops and the leaves of the cane as previously described.

Root disease is sometimes troublesome in cane. It is caused by a fungus that lives over from year to year in the soil or in diseased plants. Burning the cane litter and planting canes free from the disease are preventive measures.

Red-cane. — A discoloration of the interior of the stem occurs if cuts and bruises are made on the outside. If injured canes are planted, the disease may be harmful.

COTTON

129. The cotton plant. — The fibers of cotton make a large part of the thread and cloth used by mankind and, in addition, the seeds are valuable in many ways. Cotton is grown in warm climates. The southern part of the United States produces about three-fourths of the world's cotton crop. It is also grown to a limited extent in southern California. India and Egypt follow the United States with considerably smaller productions.

The plants vary in height from low-growing shrubs to trees twenty feet high. In the South the commercial variety is the product of plants averaging from two to six feet high. The tree form grows only in tropical countries and is not commercially important. In such regions the plant is a perennial, but in this country it is grown as an annual. The plant has an erect stem with several branches (Fig. 95). The root-system consists of a tap-root with several branching roots

growing from it within three or four inches of the ground. Cotton is really a shallow feeder. The plant is somewhat cone-shaped, the lower branches being the longest and the length decreasing toward the top. Two kinds of branches,

Fig. 95. — Cotton plant.

known as vegetative and fruiting, are found on the plants. The vegetative branches have many leaves and do not usually produce many bolls. The fruiting branches have few leaves and produce most of the bolls.

The stems are covered with a fairly tough bark and the inside is brittle; consequently after the crop has been harvested, the old plants can be broken down readily. The leaves are arranged alternately and are usually three-lobed, although they vary in shape in different varieties and often on the same plant.

The flowers are large and are attached to the stems by short branches. In the upland varieties, the blossom is white or pale cream on the first morning and changes to a pink or red on the second day. The petals fall on the third or fourth day. In the sea-island varieties, the blossom the first morning is yellow with a purple-red spot at the base of each petal. The flowers of cotton have five large petals and five inconspicuous sepals. The base of the flower is surrounded by three to five fringed bracts. The unopened buds inclosed by the bracts make up the so-called "square" of cotton. After the petals fall there remains an enlarged base of the pistil surrounded by the bracts. The enlarged pistil is the seed-pod. As this develops the bracts fold backward and the divisions, or locks, separate, exposing the white, fluffy mass of fiber and seeds. The pistil is divided into three to six parts and the number is the same as that of locks of seed cotton that develop in the boll.

The single fibers of cotton are very small. Each is an elongated, twisted tube. The twists in a fiber are what cause threads to hold together when the cotton is spun into yarn. Because it will make a stronger yarn, cotton with a large number of twists in the fiber is more valuable than that with a comparatively few twists. Maturity of fiber is of importance, as immature fibers have but a few twists and thus make weak threads. For this reason cotton should not be picked until the bolls are well opened and mature. The length of the fiber also determines its value, a long fiber being more valuable than a short one.

130. Types of cotton. — The most important type of cotton grown in the United States is the American upland, which is of two classes, the short-staple and the long-staple. In the

short-staple, the different fibers vary in length from three-quarters of an inch to one and one-eighth inches and in the long staple from one and one-quarter inches to one and five-eighths inches. Long-staple cotton is of much more value than short-staple, but usually the acre yield is less. A large proportion of the upland cotton grown in the United States is short-staple, but of recent years improvement has been made in varieties by careful seed selection and larger acreages of long-staple are being grown.

The other type is sea-island cotton. The lint is much longer than that of long-stapled upland, the usual length being from one and one-half to two inches. The yarn from these fibers is used in making the finest fabrics. The price is much higher than for upland cotton, but the acre yield is less and it is more difficult to pick and gin. This type can be grown only where the climate is even and moist and where there is no danger from frost. The areas in the United States where it is produced are along the coast and on nearby islands of South Carolina, Georgia, and Florida.

131. Uses of cotton. — The principal use of cotton is for making thread and cloth. The seeds are, however, of considerable value. They are sometimes used as fertilizer by the southern planters, but this practice is much less common than formerly. The seeds now are usually sold to the oil mills, where the oil they contain is extracted and refined. Cottonseed oil is used as a substitute for olive oil and for making soap and lard substitute. The portion of the seed that is left is valuable as a dairy feed. It is high in protein and is one of the chief products used by dairymen to increase the protein-content of the rations fed to the cattle. It is also valuable as fertilizer. Before extracting the oil, the hulls are removed. These are used by some southern planters as dairy feed. They contain, however, chiefly cellulose and thus their chief value is to furnish bulk to the ration. They are sometimes used as a fertilizer, but for this purpose are of no considerable value.

132. Soils and fertilizers. — Cotton will grow on almost any soil from a light sand to a heavy clay. Light soils are not especially good for this crop, because of injury from cotton rust that is likely to occur. Nevertheless, they are often planted and yield good crops. Loamy soils or clays are better. The soil must not be too rich for there is likely to be an excessive stalk development at the expense of the bolls.

The South has found the use of fertilizer for cotton to be profitable. The experiment stations have done much toward determining the best fertilizer for cotton lands of their states and the results of the determinations are recorded in bulletins that are sent free to the residents of the state on application. Farmers should take advantage of these publications.

C. B. Williams, agronomist, North Carolina Experiment Station has made an extensive study of the fertilizer requirement for cotton-growing on both the Coastal Plain and the Piedmont Plateau soils of the South and makes the following recommendations:

For the Coastal Plain soils, six hundred to eight hundred pounds or more to the acre of one of the following mixtures should be used.

No. 1.	Pounds
Acid-phosphate, 16 per cent phosphoric acid	300
Cottonseed meal, 6.17 per cent nitrogen, 2.8 per cent phosphoric acid, and 1.8 per cent potash	1400
Kainit, 12 per cent potash	300
	2000

This mixture will contain: Available phosphoric acid, 4.4 per cent; potash, 3.1 per cent; nitrogen, 4.3 per cent (equal to ammonia, 5.2 per cent).

No. 2.	Pounds
Acid-phosphate, 16 per cent phosphoric acid	460
Cottonseed meal, 6.17 per cent nitrogen, 2.8 per cent phosphoric acid, and 1.8 per cent potash	770
Nitrate of soda, 15 per cent nitrogen	320
Kainit, 12 per cent potash	450
	2000

In this formula one-half of the nitrogen is supplied by nitrate of soda, and the other one-half by cottonseed meal. This mixture will contain: available phosphoric acid, 4.8 per cent; potash, 3.4 per cent; nitrogen, 4.8 per cent (equal to ammonia, 5.8 per cent).

No. 3.	Pounds
Acid-phosphate, 16 per cent phosphoric acid	330
Cottonseed meal, 6.17 per cent nitrogen, 2.8 per cent phosphoric acid, and 1.8 per cent potash	1590
Muriate of potash, 50 per cent potash	80
	2000

This mixture will contain: available phosphoric acid, 4.9 per cent; potash, 3.4 per cent; nitrogen, 4.9 per cent (equal to ammonia, 6 per cent).

For the Piedmont Plateau soils, the same quantity of one of the mixtures listed below should be used.

No. 1.	Pounds
Acid-phosphate, 16 per cent phosphoric acid	1125
Cottonseed meal, 6.17 per cent nitrogen, 2.8 per cent phosphoric acid, and 1.8 per cent potash	640
Kainit, 12 per cent potash	235
	2000

This mixture will contain: available phosphoric acid, 9.9 per cent; potash, 2 per cent; nitrogen, 2 per cent (equal to ammonia, 2.4 per cent).

No. 2.	Pounds
Acid-phosphate, 16 per cent phosphoric acid	1235
Cottonseed meal, 6.17 per cent nitrogen, 2.8 per cent phosphoric acid, and 1.8 per cent potash	700
Muriate of potash, 50 per cent potash	65
	2000

This mixture will contain: available phosphoric acid, 10.9 per cent; potash, 2.3 per cent; nitrogen, 2.2 per cent (equal to ammonia, 2.7 per cent).

133. Rotations with cotton. — Leguminous crops grown either as green-manure or as forage crops in rotation with cotton are especially useful in keeping up the plant-food and

humus supply of the soils of the South. Where cotton is grown in rotation with other crops and legumes are made a part of the rotation, a very good soil condition is obtained. C. B. Williams advises the following rotations for North Carolina.

For the Coastal Plain:

First year. — Cotton.
Second year. — Rye or oats, followed by cowpeas or soybeans to be plowed into the soil.
Third year. — Corn, with cowpeas; or
First year. — Cotton, with crimson clover sown broadcast after the first picking.
Second year. — Corn, with cowpeas.
Third year. — Small grain followed by cowpeas or soybeans.

For the Piedmont Plateau:

First year. — Cotton, with rye sown after the first picking.
Second year. — Corn, with cowpeas.
Third year. — Wheat sown the previous fall, and red clover sown on the wheat during the early spring.
Fourth year. — Red clover.

134. Cultural methods. — Cotton is very often planted on land that has been in cotton the previous year. The first step in preparing for another crop is to break down the old stalks and chop them into pieces that can be turned under by means of a plow. An implement known as a stalk-cutter is useful for this purpose. When a stalk-cutter is not available, the stalks are generally beaten down with a stick. Where the cotton boll-weevil is prevalent, it is often necessary to burn the old stalks. This is done in the early fall before the weevils hibernate for the winter. The stalks should be turned under when possible, as they add humus to the soil.

Plowing. — Most of the fields for cotton are plowed in February and March. Some growers plow as early as November or December; others just previous to planting, which date varies according to the locality. Late plowing is not advised.

Early plowing on clay soils is an advantage, as the freezing in winter aids in pulverizing the soil. If the land becomes too compact before planting time, it should be plowed again or disked. Sandy land should not, as a rule, be plowed too early on account of the tendency of plant-food to leach away. All fall-plowed land should have a cover-crop to prevent the loss of fertility by leaching and washing. This land should be plowed again in the early spring; this gives the green plants time to decay somewhat before the cotton is planted. Deep plowing is advised as it gives more room for the roots. If, however, the land has always been plowed shallow, the depth should be increased gradually, because too much subsoil thrown up by the plow is a disadvantage.

Ridging the land. — Fields to be planted to cotton are usually ridged, four or more furrow slices made with a one-horse plow being thrown together to form a bed three or four feet wide and several inches higher than the furrow between them. If fertilizer is to be used, a furrow is plowed in the middle of the space where the bed will be made and the fertilizer placed in it. Later the ridge is made and the seed planted in a row above the fertilizer.

Date of planting. — The time of planting is controlled largely by the usual date of the last killing frost in the region. As this date varies in different sections, the time of planting cotton also varies. In the northern part of the cotton-belt, planting is often not done until May. In the southern part it is generally begun in March.

Planting the seed. — Most of the cotton is planted with a one-horse planter (Fig. 208). The usual depth of planting is from one to three inches; on cloddy, dry soils the depth is deeper than in well prepared moist soils. From a bushel to a bushel and a half of seed an acre is usually sown. If the seeds all sprout, this provides too many plants, but the surplus are later hoed, or "chopped," out. The plants are left from twelve to sixteen inches apart in the row after thinning.

Cultivating the field. — When the plants are a few inches high, they should be cultivated with a harrow or weeder. From four to six cultivations and two or more hoeings should be given a field during the growing season. A good rule to follow is to cultivate after each rain before a crust has formed. Shallow cultivation, especially after the plants have attained some size, is advised, because the branching roots of the cotton plant do not go deep into the soil.

135. Harvesting the crop. — Most cotton is picked by hand. Several mechanical pickers are on the market, but they are not entirely satisfactory. The picking is one of the most expensive operations in cotton culture. Fig. 96 shows a field of cotton ready to be picked. Following the picking the cotton is ginned — that is, the seeds are removed. The cotton-gin separates the seed from the fiber, or lint, by means of saw-like wheels. The lint after the removal of the seeds is packed by hydraulic pressure into bales of about five hundred pounds in weight. It is then ready for sale.

136. Pests of cotton. — The boll-weevil and the boll-worm are the two most troublesome insect pests of cotton, and cotton-wilt and root-rot are the two most troublesome diseases. Only brief mention can be made here of these pests. For a full discussion see the publications on the subject sent out by the United States Department of Agriculture and the experiment stations of the Southern States.

Boll-weevil. — The adult weevil is a grayish insect about one-third of an inch long with a snout about half as long as its body. The female lays its eggs in the bracts and the immature bolls. The larvæ eat into the boll and destroy its center. The methods of combating the pests are preventive. The weevils are most numerous late in the season. For this reason an early crop is desired. To attain this end, warm, early soils are selected as the areas to be planted to cotton, early varieties are chosen and planted as soon as the weather permits, and the ground is well fertilized and cultivated frequently.

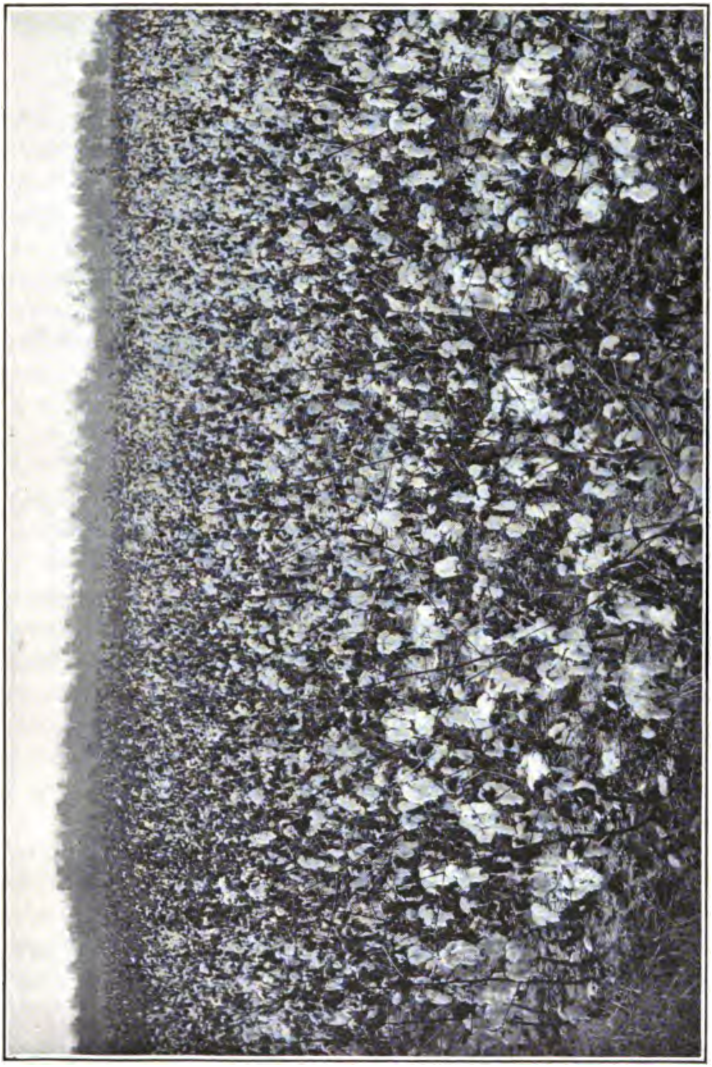

Fig. 96. — Cotton in the boll.

In the spring fallen squares which contain larvæ are picked up and burned. In the fall the stalks of the cotton are burned or plowed under to kill as many weevils as possible before they hibernate.

Boll-worm. — The same insect as the corn ear-worm previously described when found on cotton is known as the boll-worm. The females lay eggs on all parts of the cotton plant, but more especially on the leaves. The larvæ that hatch eat at first into the tender buds and the surface tissue of the leaves. At this stage they can be poisoned, but this practice has not been found very practicable. Preventive measures are better. As the worms become older, they cut into the boll and destroy its contents. When they become full size, they drop to the ground and usually burrow to a depth of two or three inches, where they remain during the pupal stage. From the pupa the moth emerges.

The preventive measure usually followed is to plant trap crops of corn, one about the first of June and the other two weeks later. This will bring the corn into the roasting ear stage during the first weeks of August. The moths prefer corn in the roasting ear stage to cotton; consequently they will deposit their eggs on the corn rather than on the cotton and thus the latter will not suffer much from the ravages of the larvæ. The trap crops of corn are often planted in oat fields near the cotton or two or three rows of corn are planted in the cotton fields, alternating with thirty or forty rows of cotton.

Another preventive measure is late fall or early winter plowing. This destroys the burrows of the insects and upturns many of the pupa to the cold weather of winter.

Cotton-wilt. — This is a very troublesome disease, especially on some soils. It occurs any time after the plants are about six inches high. The plants suddenly wilt and usually die in a few days. To plant no cotton on the ground for three years and to use wilt-resistant varieties will sometimes prove

successful in combating the disease. Planting a grain crop on the ground in the fall and following the next year with a crop of cowpeas of the iron variety is a method used by some farmers to prevent the disease.

Root-rot. — The plants affected with rot wilt suddenly and later die. Deep fall plowing and the growing of some other crop on the land for a few years are of use in fighting the disease. In choosing a crop in place of the cotton, the planters must avoid sweet potatoes and alfalfa, which are also attacked by root-rot.

TOBACCO

137. Tobacco-growing districts. — The tobacco plant may be grown successfully in all latitudes of the United States and on a great variety of soils. But the value of the crop is influenced so much by the climatic and soil conditions under which it is grown that the industry has become specialized in certain districts and it is there that the trade seeks the product. Each special district produces a certain type of tobacco and the methods of growing and handling the crop vary according to the type of leaf that it is desired to produce. General cultural methods are, however, somewhat similar.

138. Classes of tobacco. — Three general classes of tobacco are grown, (1) cigar tobaccos, (2) export tobaccos, and (3) manufacturing tobaccos. Cigar tobaccos are those to be made into cigars, export tobaccos are those to be sent abroad, and manufacturing tobaccos are those to be used in the making of products other than cigars. Each of the general classes may be subdivided into types. For example, cigar tobaccos may be wrapper leaf, binder leaf, or filler leaf. In export and manufacturing tobaccos are such types as flue-cured, Virginias uncured, and white burley. Each of the different types is produced on a special kind of soil and according to different methods of curing and handling. Cigar tobaccos are grown chiefly in certain sections in Connecticut, Massachusetts, New York, Pennsylvania, Ohio, Wisconsin, Florida, Georgia, and Texas.

Export and manufacturing tobaccos are grown chiefly in sections in Tennessee, Kentucky, Ohio, Virginia, Indiana, South Carolina, North Carolina, and Louisiana.

139. Methods of securing tobacco seedlings. — The seeds of tobacco are very small and are planted in hot-beds or cold-frames. On reaching a certain size, the seedlings are transplanted to the field by hand or by a transplanting machine. The ground where the seed-bed is to be situated is usually sterilized to kill weed seeds and disease spores. This is most commonly accomplished by means of steam. Steam from a portable boiler is forced into an inverted metal box placed over the soil of the seed-bed until the soil at a depth of four inches is at a temperature of 175° F. After an hour the metal box is removed and the process repeated on another section of the soil.

The rate of seeding in the bed varies in different sections of the country. A teaspoonful of seed to one hundred square feet of bed is about the average, although some growers sow this quantity on two hundred square feet. In order to secure an even distribution, the seed is mixed with two quarts of land-plaster, bone-meal, or finely sifted wood-ashes. The seeds are covered by pressing them into the soil with a plank or a roller. After sowing the seed, the beds are covered with cheese-cloth or glass. The soil is watered frequently, but it must not be kept too wet. Ventilation in the bed is necessary and the temperature must not get high enough to burn the plants.

140. Cultural methods. — The field where the plants are to be set must be put into good physical condition. The methods of fertilizing the soil vary in the different sections and with the type of tobacco grown. The spacing of the plants in the fields varies with the type of tobacco, ranging from rows thirty-four to forty inches apart with plants fourteen to twenty-eight inches apart in the rows. In some sections the plants are grown in hills varying from thirty-two to thirty-six inches apart each way.

The field is cultivated frequently during the growing season, beginning soon after the plants are set and continuing until they become too large for the cultivators to be pulled between the rows.

Topping the plants is a method practiced in tobacco culture. This consists in removing the flower-buds and a portion of the top. The nourishment that would be used to develop these parts is sent into the leaves and causes a better

Fig. 97. — Field of tobacco.

development of leaf, which is the valuable part of the plant. After the plants have been topped, they send out suckers from the axils of the leaves; if these were allowed to grow they would rob the leaves on the main stalk of fertility. To offset this the suckers when about two inches long are removed (Fig. 97).

141. Harvesting and curing. — Tobacco is harvested either by cutting off the whole plant or by removing the leaves as they ripen; not all ripen at the same time. In the former method the stalks are cut off close to the ground as soon as

the middle leaves turn light green. The plants are carefully laid on the ground where they remain until the leaves have wilted enough to avoid much breaking when handled. Each plant is then hung on a four-foot lath by piercing it near the base with a steel point attached to the end of the lath (Fig. 98). Usually six plants are placed on a lath and these are hung on racks on the wagon and hauled to the curing barn. They are hung in tiers with a space of six to twelve inches between the laths. When harvesting by the second method, the

Fig. 98. — Harvesting tobacco by cutting the stalk, showing method of spearing the plant on the stick.

leaves as they ripen are picked from the plants, five pickings usually being made. The leaves are laid in the spaces between the rows and later carried to the curing barn where they are strung on cords attached to four-foot laths. These laths with the plants are hung in the barn where the leaves cure.

The method of curing varies with the type of tobacco. In the air-cured method the barn is provided with ventilators which are opened to secure ventilation and the tobacco is then subjected to a slow air curing. In the fire-cured method the tobacco in the barn is treated by artificial heat.

QUESTIONS

1. What is the difference between cane sirup and molasses?
2. Why is a plentiful supply of water necessary in soils planted to sugar-cane?
3. In Louisiana why are the tops and leaves of sugar-cane that are left in the fields burned each year?
4. Describe the methods employed in harvesting sugar-cane.
5. Describe vegetative and fruiting branches of cotton.
6. Describe the cotton blossom.
7. What qualities determine the difference in value of the various lots of cotton?
8. Tell the difference between long-staple and short-staple upland cotton.
9. Why is sea-island cotton not grown on the Piedmont section of the South?
10. State the uses of cotton and of cotton seed.
11. Why should shallow cultivation be employed for cotton?
12. What methods are used to combat the boll-weevil? the boll-worm?
13. Why is tobacco not grown in more sections of the country?
14. Define: cigar tobacco, export tobacco, and manufacturing tobacco.
15. Why is the ground sterilized where a tobacco seed-bed is to be planted? How is this usually done?
16. How is an even distribution of the seed secured in the tobacco seed-bed?
17. What is meant by the topping of tobacco plants and why and how is this done? Why is it necessary to sucker the plants?
18. Describe the two methods of harvesting tobacco.

EXERCISES

1. **Propagation of sugar-cane.** — Examine a stalk of sugar-cane and notice the buds at each node. Describe their size and arrangement on the stem. In the fall collect several stalks of cane. Protect half of them during the winter by a covering of soil and allow the other half to be exposed to the weather. In February or March plant some of each lot of cane and observe the results. Examine the buds of those that remain by cutting lengthwise through them. Is there a difference in appearance of the buds?

2. **Characteristics of sugar-cane.** — Secure plants, roots, and stems of sugar-cane, corn, wheat, and a tall-growing grass and compare them. To what family does sugar-cane belong?

3. **Cropping methods for sugar-cane.** — Visit cane fields at the planting, cultivating, and harvesting seasons and write description of the methods followed. Visit, also, a cane mill while in operation and study the methods of making sugar and molasses.

4. **Characteristics of the cotton plant.** — In the fall visit a cotton field and study the characteristics of the plants. Notice the root system, the kind of stem, the shape of the plant, the vegetative branches, the fruiting branches, the arrangement of the leaves, the shape of the leaves, the parts of the flowers, and the shape of the bolls (bolls and flowers are in the field at the same season), the number of locks, and the length of the fiber.

5. **Pests of cotton.** — Study the life history of the boll-weevil and the boll-worm and if these pests are prevalent in your vicinity, visit the fields to study the insects, and their work. Write to your state experiment station and the United States Department of Agriculture for publications about these insects. Follow the same plan for cotton-wilt and root-rot.

6. **The judging of cotton.** — Using the score-card below, judge several samples of cotton. For complete directions concerning cotton judging see United States Department of Agriculture Bulletin 294.

SCORE-CARD FOR THE COTTON PLANT

THE COTTON PLANT	SCORE		
	Perfect	Student's	Corrected
Plant, vigorous, stocky, 25 points:			
Size, medium to large as influenced by soil, location, season, and variety	5	....	...
Form, symmetrical, spreading, conical, height, and spread according to soil, etc.	5	....	....
Stalk, minimum amount of wood in proportion to fruit	5	....	....
Branches, springing from base, strong, vigorous, in pairs, short-jointed, inclined upward	5	....	....
Head, well branched and filled, fruited uniformly	5	....	....

SCORE-CARD FOR THE COTTON PLANT (*Continued*)

THE COTTON PLANT	SCORE		
	Perfect	Student's	Corrected
Fruiting, 24 points:			
Bolls, large, abundant, uniformly developed, plump, sound, firm, well rounded, apex obtuse, singly or in clusters	4	....	....
Number of bolls, according to variety, soil, and season	4	....	....
Bolls per plant, thin uplands, 10–20; fertile uplands, 20–25; "bottoms," 50–100; special selection, 100–500	4	....	....
Bolls per pound of seed cotton, large, 40–60; medium, 60–75; small, 80–110	4	....	....
Character of bolls, number of locks 3 to 5; kind of sepals; retention of cotton	4	....	....
Opening of bolls, uniform including top crop, classify as good, medium, poor	4	....	....
Yield — standard 1 bale per acre, 30 points:			
Seed cotton, estimated by average plant, distance of planting, per cent of stand, plants per acre; thin uplands, 10,000; fertile uplands, 6500; "bottoms," 4500; distance of plants $3\frac{1}{2}$ by $1\frac{1}{4}$ feet, $4\frac{1}{2}$ by $1\frac{1}{2}$ feet, $4\frac{1}{2}$ by 2 feet, respectively	12	....	....
Per cent lint, not less than 30, standard 33 to 35	12	....	....
Seeds, 30–50 per boll, large, plump, easily delinted, color, according to variety; germination not less than 95 per cent	6	....	....
Quality and character of lint, 21 points:			
Strength, tensile strain good, even throughout length	5	....	....
Length, common standards for upland, short $\frac{7}{8}$ to 1 inch, premium $1\frac{1}{16}$ to $1\frac{1}{8}$ inches; long staple, $1\frac{3}{16}$ inches and better	5	....	....
Fineness, fibers soft, silky, and pliable, responsive to touch	5	....	....
Uniformity, all fibers of equal length, strength, fineness	5	....	....
Purity, color dead white; fiber free from stain, dirt, and trash	1	....	....

No. of plant.............. Source..............................
Type..
Remarks on plant...
Date................, 19.... Name of student.................

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CHAPTER XII

FRUIT-GROWING

Classification of fruits.
Soils for fruits.
Air drainage in fruit-culture.
Pruning of fruit-trees.
  Need for pruning.
  Winter and summer pruning.
  Tools used for pruning.
  How to remove a branch.
Spraying of fruit-trees.
  Materials used for spraying.
  Equipment for spraying.
  Spray schedules.
Cultural methods.
  Time for planting.
  Distances for planting.
  Systems of planting.
  Trimming the nursery trees.
  Preparation of the soil.
  Clean cultivation and sod culture.
Harvesting of fruit.
Pests of fruit plants.
  San José scale, codlin-moth, apple-tree tent-caterpillar, plant-lice, leaf blister-mite, bud-moth, plum curculio, borers, apple-scab, bitter-rot, brown-rot, apple-blotch.

The growing of fruit is for two purposes: to produce a supply for home use, and to obtain revenue from a product grown for market. There are so many species of fruit plants, and so many varieties of each fruit, that the home-maker has almost endless choice. The entire year can be covered in many parts of the country, from the last winter apple to the strawberry and other small-fruits, cherries, apricots, grapes, peaches, plums,

pears, and others. In warm regions, the persimmon and citrus fruits, and many others, are grown. The home fruit plantation should be encouraged as a source of supplies and pleasure.

Commercial fruit-growing has now reached a great development in North America. This is particularly true of apples, peaches, and citrus fruits. Great attention has been given to the insects and diseases affecting the fruit crops, and also to methods of handling the products. As fruit-trees will continue to bear even under neglect, careless growers are likely to give little attention to them; yet these plants respond to good care as readily as others, and it is only under the best conditions that profitable production is to be expected.

142. Classification of fruits. — The growing of fruit is a very important agricultural pursuit in the United States. Some kind of fruit is produced on most farms and in many sections the growing of fruit is the chief industry. According to Bailey, fruits may be classified under four heads: (1) tree-fruits, including apples, pears, quinces, apricots, plums, cherries, nuts, figs, and olives; (2) vine fruits, including grapes; (3) small-fruits, including currants, blackberries, raspberries, and strawberries; (4) herb-like fruits, including bananas and pineapples.

143. Soils for fruit. — Some kinds of fruits are more exacting as to soil than others. Apples, plums, and citrus fruits seem to grow fairly well in most kinds of soil, although there is in each region where these fruits are grown a soil type that is best suited to each. Pears do best on clay soil and peaches on sandy soil.

The drainage of land devoted to fruit-culture is very important; often the reason for lack of success in this husbandry is poor soil drainage. The subsoil is of as much importance as the surface soil in determining fruit adaptation to land. A soil with an impervious subsoil near the surface means one with a shallow zone for the tree roots. Such land should not be planted to fruit.

144. Air drainage in fruit-culture. — An important factor in fruit production is air drainage. Cold air is heavier than warm air and drains down hill and remains in low places, and these areas are more subject to frost than higher areas. Frost at blossoming time will injure the blossoms. Often when orchards are planted on hillsides, the blossoms on trees near the bottom of the hill will be injured by frost, while those higher up the slope will escape damage. Thus the selection of a site where late frosts seldom kill the blossoms is of importance.

FIG. 99. — Peach tree in need of pruning.

145. Pruning of fruit-trees. — A phase of work that must be given proper attention by an orchardist is the pruning of the trees. Pruning means the removal of certain branches. This is done in order to allow the remaining ones sufficient room and light for proper development. Figs. 99 and 100 show a peach tree before and after pruning. Most trees produce too many branches. In trees that grow naturally, the surplus branches are crowded out by

adjacent ones — that is, nature prunes the trees. In growing fruit, the orchardist must do this if he is to secure the full benefits from his trees.

Need for pruning. — On trees that grow very tall, it is usually good practice to cut back the main branches, thus giving the tree a more spreading form in order that it may be easily sprayed and cared for and the fruit easily gathered. Often pruning is done to lessen the ravages of such diseases as blight and canker. These diseases spread rapidly from branch to branch and from tree to tree, and the removal of diseased branches may prevent the spread. It is always good practice to remove and burn any diseased portion of a fruit-tree. Trees planted at regular distances apart must be pruned or their branches will grow together and interfere with the orchard operations. Also, trees like the peach, which bear fruit on the new wood at the outside of the tree, should be pruned regularly in order that the weight of the fruit be kept near the body and main branches.

FIG. 100. — Same tree as shown in Fig. 99 after pruning.

Winter and summer pruning. — Pruning at different seasons of the year has different effects on the tree. Pruning in winter

tends toward the production of branches and leaves; pruning in summer, toward blossoms and fruit production. In a rightly pruned orchard, there is a balance between these growths. Excessive pruning in the winter will result in the formation of many water sprouts and much foliage, and the production of fruit will be checked. Excessive pruning in the summer will often diminish the wood growth too much. In practice orchardists prune their trees a little each winter, and in the summer, whenever they see a branch that should be removed, they cut it off. If a young orchard is properly pruned from the beginning, the trees will be kept in a good balance and the best results obtained. If pruning is neglected, poor results must be expected.

Tools used for pruning. — Knives, shears, and saws are the tools used in pruning. For small trees knives and shears are all that are usually necessary; for large trees saws must sometimes be used. Several types of saws are on the market and care must be taken to select a kind that will not injure adjacent branches. Saws with teeth on both edges of the blade are not satisfactory, because they are likely to saw into the wood of an adjacent branch.

How to remove a branch. — When removing a branch, one should be sure to cut close to the parent branch. Stubs left on the tree are a source of injury; the wood of the stub soon decays and this decay enters the tree. When pruning off a large limb, care should be taken to avoid splitting the limb to which it is attached. A cut should first be made an inch or so into the limb on the under side, then an incision cut on the upper side about an inch or so nearer the parent branch. The limb can then be sawed off. Without this precaution the weight of the limb may cause the bark on the lower side to split and be carried down on the parent branch. After the cuts have been made in this way the wound should be trimmed close to the tree. All wounds except small ones should be painted over with white-lead paint or some wound dressing to stop the entrance of rot-producing organisms.

146. Spraying of fruit-trees. — Like pruning, spraying is an important detail of orchard management. Fruit-trees are subject to many insect and fungous pests and it is necessary to combat these successfully if profitable crops are to be produced.

Materials used for spraying. — Insecticides and fungicides are used as spray materials to fight the pests. An insecticide is any substance that kills insects and a fungicide is any substance that kills fungi. Insecticides are of two general classes — poisonous and contact. The former contain poison and are used to kill insects with biting mouth parts. Those most used are arsenate of lead, paris green, arsenite of lime, london purple, and hellebore. All these, except hellebore, contain arsenic in some form. Hellebore is made from the roots of the white hellebore. A contact insecticide is a substance used to kill insects by coming in contact with their bodies. Insects with sucking mouths cannot be killed by means of poison and must, therefore, be combated with contact insecticides. Plant-lice and the scale insects are usually killed in this way. The chief contact insecticides are boiled lime sulfur, self-boiled lime sulfur, miscible oils, distillate oils, kerosene emulsion, and tobacco preparations.

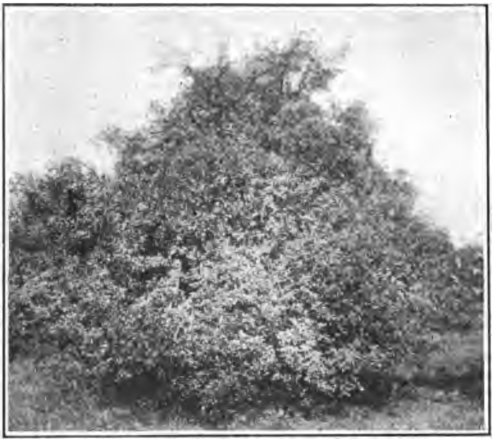

FIG. 101. — Sprayed trees in same orchard as shown in Fig. 102.

The fungicides used in combating the fungi of fruit-trees

are usually some solution containing copper. The chief ones are bordeaux mixture, ammoniacal copper carbonate, copper-sulfate solution, sulfur dust, potassium sulfide, boiled lime sulfur, and self-boiled lime sulfur.

In addition to the insecticides and the fungicides listed, many proprietary preparations are on the market, a number of which give excellent results. As a rule, they are somewhat easier to prepare for use than the home-made mixtures and for this reason are often preferred.

Many of the insect and fungous pests occur on the fruit-trees at the same time and, when the mixing will have no injurious effects on the trees, orchardists combine the insecticides and fungicides and apply them at one spraying.

Fig. 102. — Unsprayed trees in same orchard as shown in Fig. 101.

Figures 101 and 102 show the beneficial effects of spraying. Fig. 101 illustrates sprayed trees and Fig. 102 unsprayed trees in the same orchard. Notice the difference in the foliage of the trees.

Equipment for spraying. — An orchardist has his choice of many types of sprayers when purchasing equipment. The outfits range from small knapsack sprayers and barrel outfits to gas power outfits. Figs. 103 to 105 show various types of equipment for spraying.

Spray schedules. — To be effective, spraying must be done thoroughly and at the life period of the insect and fungus during

Fig. 103. — Gas-engine sprayer.

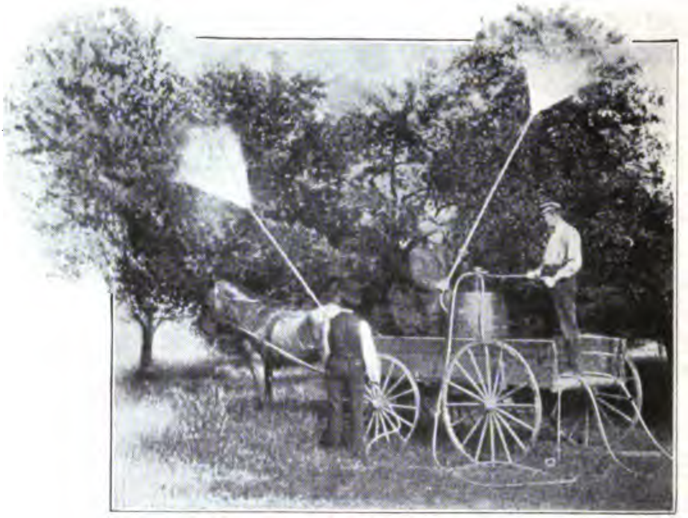

Fig. 104. — Hand-power sprayer.

FIG. 105. — Knapsack sprayer.

which they can be killed. The life histories of the pests have been studied by scientists and the best time to combat each of them has been determined. To aid the orchardist, spray schedules are prepared. A general schedule of sprayings for apples, pears, peaches, plums, cherries, quinces, apricots, currants, gooseberries, and grapes is given on the next few pages. With the exception of the part dealing with grapes, it has been reviewed by John W. Roberts, in charge of orchard spraying experiment in the Office of Fruit Disease Investigations of the United States Department of Agriculture. The schedule for grapes is from a Government publication. The descriptions of most of the pests are given in the last part of the chapter.

Spray Schedules

Apples

First Spraying.

During the dormant season preferably just as the leaf-buds are swelling, but before they are open, spray with lime sulfur solution that has been diluted to a specific gravity of 1.03. To each fifty gallons of spray material add two pounds of arsenate of lead paste. The lime sulfur is for the San José scale and the arsenate of lead is for the leaf blister-mite, the bud-moth, and the cigar-case bearer. This spray is often called the dormant spray.

Second Spraying.

About the time the fruit blossoms start to look pink at the tips, but before they are open, spray with lime sulfur diluted to 1.007 specific gravity, with two pounds of arsenate of lead paste added to each fifty gallons of spray material. This spray is to combat the bud-moth, the cigar-case bearer, the canker-worm, the tent-caterpillar, and the apple-scab. The scab is combated, because the lime sulfur is a fungicide as well as an insecticide. This spray is often omitted in commercial orcharding, but it usually pays in the home orchard.

Third Spraying.

After about two-thirds of the petals have fallen from the trees, spray with the same mixture as given for the second spray. This is to control the codlin-moth, canker-worms, the bud-moth, apple-scab, and the leaf-spot. This spray should never be omitted, as it is the most important of all.

Fourth Spraying.

If apple blotch is prevalent, make a fourth spraying three to four weeks after the third with arsenate of lead and bordeaux mixture, 4–4–50. This controls, in addition to the apple-blotch, the codlin-moth, the canker-worm, the leaf-spot, and the apple-scab.

Fifth Spraying.

If bitter-rot is prevalent, spray with bordeaux mixture, 4–6–50, about six weeks after the blossoms fall.

Sixth Spraying.

Spray eight or nine weeks after the petals fall with bordeaux mixture and arsenate of lead. This is for late broods of the codlin-moth and late infections of the apple-scab. Often this spray is omitted, but if fancy fruit is desired the grower will find that the spraying will pay.

Emergency Sprayings.

If at any time during the season green aphis appear, spray before the leaves begin to curl, with either of the following: whale-oil soap solution made up of one pound of whale-oil soap to six gallons of water; a tobacco preparation that contains 2.7 per cent of nicotine diluted with one hundred parts of water, or kerosene emulsion diluted one part of the stock emulsion to seventeen parts of water. The method of making the emulsion is given later.

Pears

First Spraying.

Just as the leaf-buds are swelling, spray with lime sulfur solution of 1.03 specific gravity with two pounds of arsenate of lead added to each fifty gallons of spray material. This is to combat the San José scale and the leaf blister-mite.

Second Spraying.

After the leaf-buds are open, but before the first blossoms are open, spray with lime sulfur of 1.006 specific gravity or with bordeaux mixture, 4–4–50. This is to combat the pear-scab.

Third Spraying.

When the calyxes of the fruit are still open and the petals of the blossoms are still falling, spray with lime sulfur of 1.006 specific gravity with two pounds of arsenate of lead added to each fifty gallons of spray material. This is to combat the codlin-moth, the pear-scab, and other fungous diseases.

Fourth Spraying.

From ten days to two weeks after the third spraying, spray again, using the same kind of mixture. This is to combat the codlin-moth and the pear-scab.

Emergency Sprayings.

If the pear psylla is present in the locality, spray just after the blossoms fall with kerosene emulsion, whale-oil soap, or a tobacco preparation, using the same dilutions as given for the emergency spraying of apples. Repeat the spraying at intervals of three to seven days until the pest is under control.

If the green aphis appear, spray as directed for the control of this pest on apple trees.

Peaches

First Spraying.

During the dormant season, before the buds open, spray with lime sulfur solution of a specific gravity of 1.03. This is to combat the San José scale and the peach leaf-curl.

Second Spraying.

Just after the petals fall, spray with arsenate of lead at the rate of one and one-half pounds of the paste to fifty gallons of water. This is to combat the curculio. Usually this spray may be omitted.

Third Spraying.

As the calyxes of the fruit are shedding, spray with arsenate of lead, one and one-half pounds, and lime, three pounds, to fifty gallons of water. This is to combat the curculio, the scab, and the brown-rot.

Fourth Spraying.

Three weeks after the third spraying, spray with self-boiled lime sulfur made in the proportion of eight pounds of lime and eight pounds of sulfur to fifty gallons of water. This is to combat the scab and the brown-rot.

Fifth Spraying.

Four weeks before the fruit is expected to ripen, spray with self-boiled lime sulfur. This is to combat the scab and the brown-rot. Early varieties of peaches will not require this spraying.

Plums

First Spraying.

Just before the buds open, spray with lime sulfur solution of a specific gravity of 1.03. This is to combat the San José scale.

Second Spraying.

Just after the petals fall, spray with arsenate of lead, using one and one-half pounds of the paste to fifty gallons of water. This is to combat the plum curculio.

Third Spraying.

Ten days after the petals fall, spray with arsenate of lead, one and one-half pounds, and lime, three pounds, to fifty gallons of water. This is to combat the plum curculio.

Fourth Spraying.

About two weeks after the third spraying, spray with self-boiled lime sulfur, 8–8–50 formula. This is to combat the leaf-spot and the brown-rot.

Fifth Spraying.

About a month before the fruit is due to ripen, spray with the same kind of materials as used for the fourth spraying. This is to combat the fruit-spot and the brown-rot.

Sour Cherries

First Spraying.

Just before the leaf-buds open, spray with lime sulfur solution of a specific gravity of 1.03. This is to combat the San José scale.

Second Spraying.

As soon as the petals fall, spray with lime sulfur of a specific gravity of 1.007, adding two pounds of arsenate of lead paste to fifty gallons of spray material. This is to combat the plum curculio and the different fungous diseases.

Third Spraying.

Three or four weeks after the second spraying, spray with the same kind of materials as used for the second spraying. This is to combat the same pests as listed in the second spraying.

Fourth Spraying.

In the case of late cherries, another spraying of the same materials may be applied about two or three weeks after the third application.

Fifth Spraying.

After the fruit is picked, another application of the spray material should be given. This will rid the trees of pests and be of benefit the following year.

Quinces

First Spraying.

Just before the blossoms open, spray with bordeaux mixture, 6–6–50. Add two pounds of arsenate of lead paste to each fifty gallons of the

spray mixture. This is to combat the leaf-spot, the fruit-spot, rust, and the curculio.

Second Spraying.

Just as the last petals are falling, spray with bordeaux mixture, 3–4–50. Add three pounds of arsenate of lead paste to each fifty gallons of the spray mixture. This is to combat the codlin-moth and the pests listed for the first spraying.

Subsequent Sprayings.

At intervals of about ten days, if the fruit and foliage seem to require it, spray with the same kind of materials as used for the second spraying.

Currants

First Spraying.

Before the buds open, spray with lime sulfur solution of a specific gravity of 1.03. This is to combat the San José scale.

Second Spraying.

As soon as the plants have finished blooming, spray with bordeaux mixture, 4–5–50. Add two pounds of arsenate of lead paste to each fifty gallons of the spray materials. This is to combat the currant worm and the leaf-spot.

Third Spraying.

As soon as the fruit has been harvested, spray with the same kind of materials as used for the second spraying. This is for the pests as listed in the second spraying. If the currant worm is not found on the plants at the time of the third spraying, the arsenate of lead may be omitted.

Gooseberries

First and Second Sprayings.

Spray as directed for the first and second sprayings for currants.

Subsequent Sprayings.

As soon as the berries have set, spray with lime sulfur of a specific gravity of 1.008. Every ten days repeat this spraying, using lime sulfur of this same specific gravity. These sprayings are to combat the gooseberry mildew, a very troublesome pest.

After the fruit has been harvested, spray as directed for the third spraying for currants.

Note. — The pests of raspberries, blackberries, and dewberries are not, as a rule, combated by spraying; the pests of these plants can usually be controlled by cutting out affected canes.

Grape Vines

The principal insect enemies of the grape are the grape-berry moth, the grape root-worm, the rose chafer, the grape leaf-folder, and the eight-spotted forester, all of which are eating insects; and the grape leaf-hopper and the brown grape aphis, sucking insects. The principal diseases which attack grapes are black-rot, downy mildew, powdery mildew, and anthracnose.

The use of combination spray solutions containing chemicals which act as insecticides or fungicides is advocated.

First Spraying.

About a week before the blossoms open, or when the shoots are twelve to eighteen inches long, spray with bordeaux mixture, 4–3–50, for fungous diseases, adding two to three pounds of arsenate of lead paste, or one half that quantity of the powdered form, for flea-beetle, rose chafer, and the like.

Second Spraying.

Just after the blossoms fall, spray with the same materials as in the first application for the same fungous diseases and insects and for the grape-berry moth, grape leaf-folder, and adults of the grape root-worm.

Third Spraying.

About two weeks later, use bordeaux mixture 4–3–50, arsenate of lead paste two to three pounds, 40 per cent nicotine sulfate one part to 1500 parts of the spray mixture, for fungous diseases, berry moth, eight-spotted forester, grape leaf-folder, brown grape aphis, grape root-worm, and grape leaf-hopper. To destroy the leaf-hopper, direct the spray against the lower surface of the leaves. To control the berry moth thoroughly, coat the grape bunches with the spray.

Fourth Spraying.

About ten days later or when the fruit is nearly grown, if black-rot or mildew are still appearing, spray with neutral copper sulfate or verdigris at the rate of one pound to fifty gallons of water.

147. Cultural methods. — When establishing a fruit plantation, the nursery stock must be purchased, but later a grower may produce to advantage at least a part of what he requires. The best advice that can be given concerning buying from a nursery is to deal with a reliable firm and order long enough ahead to enable them to fill the order from good stock. Inferior nursery stock should always be avoided.

Time for planting. — Fruit-trees are planted either in the fall or spring. The time depends on the climate and the kind of tree. Except in Canada and the extreme northern part of the United States, fall planting of hardy trees like the apple, plum, and pear has the advantage that the trees start to grow earlier in the spring than spring-planted trees. In the case of peaches, quinces, and grapes, spring planting is usually deemed advisable, because the roots are so sensitive to the action of freezing and thawing that they may be injured during the winter. Nevertheless, peaches and quinces are sometimes successfully planted in the fall.

Distances for planting. — Often fruit plants are set too close together. The trees and vines send out their roots for relatively long distances and too close planting means lack of food and interference with the spraying, harvesting, and other work of the orchard. Bailey gives the following as the outside average limit for fruits in the Northeastern States:

Apples	35 to 45 ft.
Apples, dwarf	10 to 15 ft.
Pears, standard	20 to 25 ft.
Pears, dwarf	12 ft. to 1 rod
Quinces	1 rod.
Peaches and nectarines	20 ft.
Plums	20 ft.
Apricots	20 ft.
Cherries, sour	20 ft.
Cherries, sweet	30 ft.
Pecans	40 ft.
Grapes	6 × 8 to 8 × 10 ft.
Currants	4 × 6 to 6 × 8 ft.
Blackberries	4 × 7 to 6 × 9 ft.
Raspberries	3 × 6 to 5 × 8 ft.
Strawberries	1 × 3 or 4 ft.
Cranberries	1 or 2 ft. apart each way

Systems of planting. — Three systems are in use for laying out orchards for tree-fruits. These are (1) rectangular, in which the trees occupy the corners of a rectangle, usually a square: (2) quincunx, in which the trees are planted in squares with an extra tree in the center of the square; often this center tree is planted as a filler to be removed when the others have attained a certain size; (3) triangular, or hexagonal, in which the trees stand equidistant throughout the field. Fig. 106 illustrates the three systems. Each of these systems requires a different number of trees for a given area when planted certain distances apart. The quincunx and triangular systems

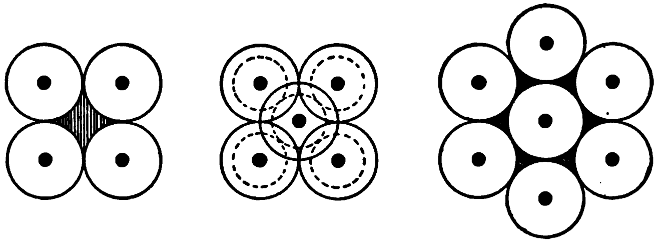

Fig. 106. — Rectangular, quincunx, and triangular systems of setting orchard trees.

permit of more trees and are often used when land is limited. The rectangular system permits of easier tillage than the others and is often preferred for this reason.

Trimming the nursery trees. — Both roots and tops of nursery trees require trimming. The tree when removed from the nursery has lost much of its root system; if planted with too much top the reduced root system would fail to care for the foliage and the newly planted tree would soon die. The trimming of the roots consists in removing any ragged ends, and if there are one or two long roots they may be cut back. No very specific directions can be given as to how much to trim the tops. The amount will be modified by the age, the shape, the species of the tree, and by the climatic conditions of the

region where the fruit plantation is to be started. In general it may be said that with one-year-old trees, the usual practice is to cut off the top leaving only a whip. In two-year-old trees, if the tops are well branched, the head is usually started at the height desired at the time of planting. A portion of the top and about half the length of each branch is removed. Fig. 107 shows the two methods of trimming the trees. To insure a clean cut, the knife blade should be placed under the branch and an upward cut made.

Fig. 107. — Nursery trees trimmed for planting.

Preparation of the soil. — Fruit plants for best results must make vigorous growth; consequently the soil must be in good condition when they are planted. The hole in which a young tree or bush is to be set should be deep and broad and surface soil should be placed in the bottom in order that the soil containing humus will be about the roots of the plants. Trees should be set an inch or so deeper than they stood in the nursery. This gives the earth room to settle and the tree will later stand at about the height it stood in the nursery. The roots should be straightened out and the soil packed firmly about them. Using the fingers to get the earth about the roots is good practice. The dirt in the hole should be tramped down once or twice during the filling. When the hole has been filled

dirt should be mounded around the tree slightly, to give it a chance to settle without forming a hollow in which water will lodge.

Clean cultivation and sod culture. — The question of tillage of fruit plantations is an important one. With bush-fruits, cultivation, as a rule, should begin in the spring, be interrupted for a time when the teams and implements would injure the fruit, and be taken up again after the fruit has been harvested, and continued until midsummer.

Grapes require frequent and thorough cultivation from early summer until after they blossom, when a cover-crop is planted to be plowed under the following spring. Peach, plum, quince, and sour cherry orchards are usually tilled from early spring until midsummer, when a cover-crop is sown. In the case of sweet cherries, too much cultivation may result in so much wood growth that the trees will not yield well. If the grower finds that clean cultivation results in smaller crops, he should keep the land between the trees in a cover-crop for two or three years.

Much difference of opinion exists in regard to the methods of handling apple orchards. Growers agree that cultivation is necessary for orchards until they reach the bearing age, but many claim that after that time the ground need not be cultivated. What is called the sod-culture system is advocated. This consists in seeding the ground to clover and some grass or other sod crop, cutting the growth, and allowing it to remain in the orchard. On certain soils and in certain climates, orchards maintained in this way have been profitable. Sod-culture does not mean that grass is cut and hauled from the orchard and used for hay. Such practice robs the ground of fertility and is not a good method to adopt. Opposed to those that believe in sod-culture, many orchardists contend that the clean cultivation of mature apple orchards is just as necessary as it is for peaches and plums. This whole question is one that is being investigated at the experiment stations, and many bulletins are being published about it.

Citrus fruits are kept in clean cultivation for a part of the year and in cover-crops the remainder. The time of the year when the land is tilled varies in the different sections. In Florida the ground is usually kept tilled from late in the fall until the beginning of the rainy season, which is about June 1. In California the ground is plowed in the spring, about March, and kept tilled until late fall, when a cover-crop is planted.

148. Harvesting of fruit. — Harvesting is a very important part of fruit-growing. Each kind of fruit must be carefully

FIG. 108. — Sorting-table lined with canvas.

handled, for bruised products will decay easily and quickly. A good method is to handle fruits as if they were eggs. When fruit comes out of storage, bruised spots show rotting quickly. Large growers are fully aware of the value of careful handling of fruit and many of them go so far as to require their pickers to wear cotton gloves to prevent finger-nail scratches and other wounds on the product. Picking receptacles should be lined

with burlap or canvas. A grain sack hung over the shoulder is poor equipment for apple picking; nevertheless they are very often used. Fruit is easily bruised by knocking the sack against the ladder and branches and in transferring it to the sorting table. When sorting fruit, as much care is necessary as when gathering it. Sorting-tables lined with burlap or canvas prevent much bruising (Fig. 108).

Grading of the product is necessary in fruit selling. A well graded basket of peaches, for example, will bring more on the market than an ungraded one. Often it pays to sort fruit to size. A basket of small apples of uniform size will usually bring as much money as a basket of large and small ones mixed.

Honesty of pack is good business. When a grower has convinced his customers that the bottom and middle of a container of fruit are as good as the top, he has done much toward selling his produce at an advance over the market price.

149. Pests of fruit plants. — An exhaustive discussion of the pests of fruit plants would require more space than can here be devoted to it. Consequently only a very few can be briefly discussed. Each kind of plant has pests that injure it, but fortunately these pests can be controlled, usually by spraying the trees with insecticides and fungicides (Figs. 103 to 105), and in some cases, as in the California citrus groves, by fumigation of the trees with hydrocyanic acid gas that is liberated underneath canvas tents placed over the trees. Fig. 109 shows the vessel in which are the materials to form the gas being placed under the tent. Nursery stock is sometimes freed of pests by fumigation, also.

It has been estimated that the work of insects alone causes a loss of over $700,000,000 each year in the United States. Much of this loss could be prevented by proper methods of combating the pests.

San José scale. — One of the most destructive pests of fruit-trees is the San José scale. Its chief damage is to tree-fruits and currant bushes. Fortunately, although this scale cannot

be exterminated, it can be controlled to such an extent that the finest fruit can be produced on trees where the pest has existed for years. To control the pest the trees and shrubs should be sprayed with lime sulfur solution.

The living scale is a very small, soft insect concealed beneath a flat, conical, water-proof protective scale. The scale can be recognized under a miscroscope by its circular shape, black tip

FIG. 109. — Fumigating citrus trees in California with hydrocyanic acid gas to kill scale insects.

at the center with a very small ring around it. Fig. 110 shows the characteristic appearance of the scale on twigs. In the winter this scale is about three-fourths the size of a pin-head and is black in color. This is known as the winter-resting stage. By spring it has increased to about the size of a pin-head and becomes brownish in color. Like other insects of this kind, it attacks its host by inserting its proboscis through

the outer bark into the sap-bearing inner bark and sometimes into the soft wood.

The females give birth to living young, the time of year varying with climatic conditions. In Pennsylvania the first brood appears from about June 1 to 15. The young are very small; without the aid of a microscope, they look like specks of corn-meal, but when magnified are seen to be oval in shape, to have heads, with eyes, antennæ, and a long thread-like proboscis. These insects crawl about on the bark and leaves of the trees for not longer than one or two days or until they find a suitable place in which to insert their proboscides and become fixed. This is usually in the bark of twigs, although it is sometimes in the leaves or the fruit. As soon as they become fixed, they begin to secrete a waxy covering which comes from the pores of their skin. Thus a scale is formed over the insect, after which it loses its head, eyes, and antennæ and does not resemble the crawling insect. The insects do not usually crawl more than five or six feet from the female that gave them birth. Often they fix very near to her, even overlapping her scale covering.

Fig. 110. — San José scale on twig (enlarged).

The young fixed scales are at first white and circular in shape and have the central point. This is their second stage. They inject poison into the plant where they are fixed, suck out sap, and grow. In a few weeks they reach the third or black stage, the winter-resting condition. They continue to grow until they reach their full size, when they are the brownish color of the adult scale. In summer this happens about a month after they are born. They then begin to bear young and this con-

tinues at the rate of several a day for a month or so. During the winter all fully grown individuals and those not old enough to have reached the protected resting condition die. About 90 per cent die naturally in this way, but there are still large numbers left. It has been estimated by the United States Department of Agriculture, that it is possible for an individual to become the ancestor of nearly a billion and a half insects in a year.

FIG. 111. — Codlin-moth larvæ in apple.

Codlin-moth. — The worms in apples, pears, and quinces are the result of the codlin-moth. These moths are found in all parts of the world and are responsible for the annual loss of thousands of dollars' worth of fruit. The mature moth is grayish brown in color and about three-fourths inch across the expanded wings. The females lay eggs on the foliage of the trees. The first lot is laid from one to three weeks after the trees blossom. In five to ten days these eggs hatch into larvæ about one-sixteenth inch in length. The larvæ, or worms, feed for a time on the leaves, but soon crawl to an apple, pear, or quince and enter it through the calyx end, in a short time eating their way to the core. They consume a portion of the flesh and the seeds of the fruit and become full grown in about three or four weeks, when they eat their way out through the side of the apple. Fig. 111 shows the larvæ in an apple. The track from the calyx end into the core and out to the side can be seen. Fig. 112 is an exterior view of young apples infested with the first brood of the moth. Notice the frass, or sawdust-like material, at the end of the apples.

When full-grown the insects are about three-fourths inch in length and are white or sometimes pinkish in color. As soon as the worms emerge, they find a convenient place, spin a cocoon, and go into the pupa state. In about four weeks they emerge from the cocoon and go into the mature moth stage. The females then lay eggs and the larvæ from these eggs enter the fruit from the sides; they are known as the second brood and are the ones that hibernate and emerge in the spring to damage the young fruit.

The insects are combated by spraying poison (usually arsenic) on the trees and by destroying the hibernating larvæ. All loose bark should be scraped from the trees and burned, as this will destroy any larvæ on the under side of the bark. As most of the larvæ of the first brood enter the fruit by eating through the blossom end, an effective way to kill them is to have a poison ready for them to eat. As the calyx closes about ten days after the blossoms fall, it is necessary to spray while this calyx is open in order to get the poison into the blossom end of the fruit. The usual time to spray is after about two-thirds of the blossoms have fallen. Later sprayings are made to kill, if possible, the insects of the second brood and any of the first brood that may have escaped the first spray.

Fig. 112. — Young apples that have been infested with the first brood of codlin-moth.

Apple-tree tent-caterpillar. — Another insect that is often troublesome on fruit-trees, especially apple trees, is the apple-tree tent-caterpillar. The silken tent containing the worms

(Fig. 113) is a familiar sight. The female lays eggs in clusters about five or six weeks after the trees have blossomed. The eggs are placed in brownish bunches around a twig and they hatch the next spring about the time the trees are leaving out. The larvæ start to eat at once and work in groups, spinning the silken web in which they stay during the night. In the day time, especially if the sun is shining, they crawl out and eat the foliage. Often a colony will strip the foliage from a large area. The insect is combated by spraying the trees with a poison before they blossom. The worms eating the poisoned leaves will be killed. It is also a good plan to burn the webs by means of a torch. To be effective, this should be done on a cloudy day, as the worms are then likely to be in the webs.

FIG. 113. — Nest and larvæ of apple-tree tent-caterpillar in crotch of wild cherry tree.

Plant-lice. — Several kinds of plant-lice attack fruit-trees. Among the most troublesome are the woolly apple aphis, the green apple aphis, the black cherry aphis, the black peach aphis, and the russet plum aphis. Methods of combating these lice are by spraying with a solution of whale-oil soap, made up in the proportion of a pound of soap to six gallons of water, a tobacco solution made up according to directions on the package, and kerosene emulsion stock solution diluted one to seventeen. The insects usually feed on the under side of the leaf and

cause the leaves to curl; hence, to be effective, spraying should be done before the leaves have curled.

Leaf blister-mite. — Of recent years much damage has been done to apple trees by the leaf blister-mite. This is a very small insect that passes the winter in the buds and early in the spring emerges and feeds on the tender foliage when the buds open. The insects are combated by spraying with lime sulfur solution during the dormant season.

Bud-moth. — In the larvæ stage the bud-moth is a dirty-white caterpillar about one-fourth inch long that sometimes attacks apple foliage. The larvæ spin a web around the leaves just as they are unfolding and eat the foliage. They are combated by the lime sulfur spray.

FIG. 114. — Adult curculios on a young peach (enlarged).

Plum curculio. — The insect known as the plum curculio (Fig. 114) attacks plums, apples, pears, cherries, and peaches. Both sexes puncture the young fruit with their proboscides for the purpose of feeding on the pulp and the female lays eggs in the punctures. About the puncture she cuts a crescent-shaped hole and this characteristic mark on the fruit can readily be distinguished. The fruits in which the eggs have been laid usually drop by the time they are half-developed, but some remain until they are ripe. When the trees are small, the young insects can be jarred from the tree. A sheet or a device known as the curculio-catcher is placed underneath the tree to catch the insects, after which they are destroyed. When the trees become large this treatment is not effective. The usual sprayings given to orchards for other insects tend to keep the curculio in check.

Borers. — Fruit-trees are attacked by borers (Fig. 115) that burrow underneath the bark of the tree near the base and in many instances girdle the tree. The only practical

a

b

Fig. 115. — The peach borer. *a*, enlarged; *b*, at work on root of tree.

way of combating these borers is to dig them out or kill them by running a wire through them in the burrow. A description of the peach-tree borer and methods of handling it will show how borers in general are combated. The female of the peach-tree borer lays eggs on the bark of the tree near the ground during the summer. These eggs hatch in a short time and the larvæ enter the bark of the tree. If not removed the borers will soon girdle the tree. An exudation of gum about the base of a peach tree usually indicates the presence of a borer in the tree. The soil should be dug away from the trunk and when burrows are found they should be opened with a knife, the insects found and destroyed; or a stiff wire may be pushed into the burrow and when the borer is reached, it should be killed by pushing the

wire through its body. The work of examining trees for borers is usually performed in May and some growers make an examination in the fall, also.

Apple-scab. — One of the most widely distributed diseases of the apple is the apple-scab. Dark, scabby spots are found on the foliage and fruit of the tree. Often the infested area will stop the growth of the fruit and cause it to assume a distorted shape. Fortunately the disease is easily controlled by spraying with boiled lime sulfur solution or bordeaux mixture. Most orchardists prefer the former, however, for spray injury to the fruit sometimes results from the use of bordeaux mixture.

Bitter-rot. — One of the most destructive diseases of the apple is bitter-rot. Early in its growth it shows as small brown spots just beneath the skin of the fruit. Later these spots enlarge and the fruit near the rotton spot is usually bitter. As the rot grows, the surface of the diseased portion becomes wrinkled. As a rule, the diseased fruits fall from the tree, but sometimes they remain, becoming later dried, wrinkled, and shriveled, in which form they are called mummies. The disease also attacks the buds and branches, causing rough, cankered areas to form on the bark. To combat bitter-rot, all diseased fruit and branches should be burned and the trees sprayed about six weeks after the blossoms fall with 4–6–50 bordeaux mixture and again in two or three weeks, if the disease is serious. Often it will pay to spray twice more at about three weeks' intervals. Lime sulfur does not seem to be an effective fungicide for this disease.

Brown-rot. — The disease known as brown-rot attacks peaches, plums, and cherries. Rot starts at a spot on the fruit and spreads rapidly. Often the fruit rots when it is small and green; in other cases, at ripening time. Many of the fruits that decay shrivel and cling to the trees all winter. These are shown in Fig. 116. Since these mummies contain spores they should always be picked from the trees or the ground and be destroyed. Until recently no effective fungicides were

known that could be sprayed on the trees while they were in leaf. Now, either self-boiled lime sulfur or a very weak solution of boiled lime sulfur is used for the purpose. If the disease is serious, several sprayings are made each year. Weather conditions have much to do with the spread of brown-rot; if bright, dry weather prevails at the time the fruit is ripening, the disease is not likely to be serious, but if hot, moist weather occurs, the spores grow very rapidly and often with such weather at ripening time, the crop may be entirely destroyed, unless the growth of the rot is prevented by timely sprayings.

FIG. 116. — Mummies of brown-rot of peach.

Apple-blotch. — A disease that somewhat resembles apple-scab is apple-blotch. On infested fruit small, light-brown, star-shaped blotches appear and spread rapidly, becoming darker in color and often joining together to form large blotches that may cover more than half the apple. Often the surface of the apple cracks. On the leaves the blotches are found as small, light-brown spots, smaller than those of the scale. On the twigs cracks in the bark are seen. The spores live through the winter on the twigs. The remedy is to spray with bordeaux mixture three or four weeks after the blossoms fall. If the disease is very bad, it is advisable to make two or three more sprayings at intervals of three weeks.

QUESTIONS

1. How are fruit plants classified by Bailey?
2. Why should land that is to be planted to fruit-trees be well drained?
3. What is air drainage and why is it an important factor in fruit-growing?
4. Define pruning and tell why we prune trees.
5. Why should stubs of limbs not be left on a tree? Tell how to remove a limb without splitting the bark of the parent limb.
6. What kind of insecticide is used to kill insects with biting mouths? With sucking mouths?
7. Define fungicide and name the chief kinds used by fruit-growers.
8. Why should fruit-trees be planted not too close together?
9. Tell how to plant a nursery tree.
10. Why must fruit be handled carefully when harvested?
11. Give the life history of the San José scale and tell how to combat this pest.
12. How may the number of wormy apples in an orchard be reduced?
13. Describe the method of combating the peach-tree borer.
14. Name two diseases of the apple and tell how they are kept in control in an orchard.
15. What spray preparation is used for brown-rot?

EXERCISES

1. **Boiled lime sulfur solution.** — One of the best materials now recognized for spraying deciduous trees infested with scale insects is boiled lime sulfur solution. It is also useful in controlling several other pests. The solution is cheap and not injurious to the trees or shrubs to which it is applied, and in addition to being an insecticide, it acts as a fungicide in controlling such diseases as scab, leaf-spot, and allied fungous troubles.

The term boiled lime sulfur solution is applied to any solution of lime and sulfur that has been produced by boiling the ingredients together over the fire or by the use of steam. The boiling causes the lime and sulfur to form a chemical combination consisting usually of several calcium sulfides. The particular sulfides formed depend on the formula used in the preparation of the solution. When a large proportion of lime is used, the lower calcium sulfides result; when the proportion of lime is small, the higher sulfides are formed. The

lower sulfides crystallize when cold and, therefore, it is advisable to use a large proportion of lime, in fact, an excess.

What is known as concentrated lime sulfur solution is the kind of boiled solution now most generally used by orchardists. This can be stored without crystallizing and used when required. The concentrated solution can be purchased from dealers or it can be made on the farm. When purchased it is known as commercial lime sulfur solution.

The formula most used at the present time in making the concentrated solution is one pound of quicklime and two pounds of sulfur to each gallon of water. These proportions are likely to form the higher calcium sulfides. The ingredients are boiled until the sulfur is dissolved. Usually this requires an hour or a little less. A good rule to follow is to boil for fifty minutes, then stir the material to see if the sulfur is dissolved. The material should not be boiled more than an hour or certain insoluble compounds are likely to be formed.

Two exercises are outlined here — one the making of the solution in the school laboratory and the other the making of it out of doors. For the laboratory exercise will be needed one pound of quicklime, two pounds of powdered sulfur, one gallon of water, a vessel in which to boil the ingredients (about two-gallon capacity), a cover for the vessel, a sieve through which to pass the sulfur, and a paddle or a glass rod for stirring the mixture. For the out-door exercise the equipment required is fifty pounds of quicklime, one hundred pounds of sulfur, galvanized washtub, boards for cover to the tub, two iron rods about five feet long and of sufficient strength when suspended horizontally to support the tub and contents, a hoe or paddle for stirring the mixture, a sieve, and several flat stones.

Any good grade of fresh quicklime can be used. Air-slaked or water-slaked lime can be used, but twice the quantity of air-slaked and three times the quantity of water-slaked are required. Commercial, or powdered, sulfur is satisfactory for making the spray.

For the laboratory exercise pour the water into the vessel, place over the heat, drop in the lime, and rub the sulfur through the sieve and into the vessel. Stir the materials to make the water cover the sulfur. As the water heats and the lime slakes, the lime and sulfur will start to unite. When the temperature of the mixture has reached the boiling point, notice the time and continue the boiling for fifty minutes. Keep the vessel closed; higher temperature will be gained and higher sulfides will result. After the ingredients have boiled for fifty minutes, stir the material and see if any uncombined material is present. If sulfur is seen boil for ten minutes longer. When the boiling is complete

remove the vessel from the heat and allow any sediment to settle to the bottom. When the liquid is cool dip and strain off the top, or red portion, and save for future use.

For the out-door exercise build up two piles of stones about a foot high and four feet apart, lay the two iron rods from one pile to the other, spacing the rods to form a support for the tub. Place the tub on the rods and pour the water into it, build a fire, and proceed with the boiling as directed for the laboratory exercises.

With two washtubs used for boiling the solution it is possible to make enough concentrate in a day to keep busy a crew with a hand sprayer fitted with two leads of hose. Five boys could make the spray and do the work of spraying an orchard; two boys to make the lime sulfur solution, one boy to work the hand pump; two boys to hold the two leads of hose.

2. **Testing lime sulfur solution.** — The density, or strength, of lime sulfur solution is tested by means of an hydrometer, an instrument made to measure the density of liquids. Two kinds of hydrometers are in use — one marked to read according to the Baumé scale and the other to read specific gravity direct. The specific-gravity type is more convenient for the orchardist, although by means of a table, Baumé readings can be reduced readily to specific-gravity readings. Instruments are made, also, on which both scales are marked. Fig. 117 shows at *a* cylinder for liquid to be tested, at *b* specific-gravity hydrometer, and at *c* Baumé hydrometer. Hydrometers can be purchased from dealers in laboratory supplies.

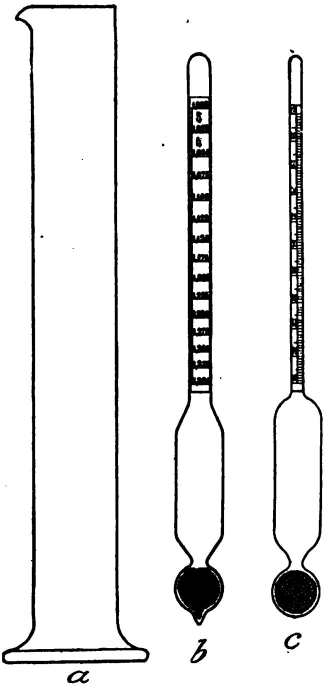

FIG. 117. — Apparatus for determining specific gravity of lime sulfur solution. *a*, Cylinder for liquid to be tested; *b*, specific-gravity hydrometer; *c*, Baumé hydrometer.

Use some of the solution made in the previous exercise; also secure a quantity from an orchardist or from a dealer. Have the liquid 60° F.

when making the test. Stir, take out a test jar nearly full, and place the hydrometer in the liquid. Next determine the ratio of dilution and dilute some of the material to a specific gravity of 1.03. To determine the ratio of dilution, divide the decimal of the specific gravity of the concentrate by the decimal desired for the dilute material. Suppose the concentrated solution tested 1.30 and it is desired to dilute to 1.03. Dividing .30 by .03 gives 10 as the ratio of dilution. The concentrate, then, contains 10 times the quantity of combined sulfides that is desired in an equal volume of dilute solutions. Thus, 1 volume of the concentrate must be added to 9 volumes of water to get 10 volumes of the desired strength. Suppose the concentrate tested 1.24. Dividing .24 by .03 the ratio is 1 to 8 and 7 volumes of water should be added to 1 volume of concentrate to make the dilute solution.

3. **Kerosene emulsion.** — An emulsion made of kerosene, soap, and water is a standard remedy for plant-lice. To make a stock solution, combine two gallons of kerosene, one-half pound of whale-oil soap with one gallon of water as follows: Boil the water and dissolve the soap in it and while still boiling hot pour the soapy solution into the kerosene (have the kerosene away from the fire). Next, churn the mixture violently for about five minutes by means of a spray-pump with a direct-discharge nozzle by throwing a stream of the liquid back into itself, or if no such pump is available, stir the material vigorously. At the end of the time the mixture should be of the consistency of cream. This stock solution is diluted for use as needed. The usual dilutions are from fifteen to twenty parts of water to one of the solution.

4. **San José scale.** — Write to the entomologist of the experiment station of your state and ask whether or not the San José scale is found in your vicinity. If so make a special trip to near-by orchards and try to find infested branches. Carry some of them to the school for further study. There is no danger of spreading the pest in this way, because when the branch dies, the scale dies also.

Draw a section of a twig as it appears under the magnifying glass. Compare the infested twigs with Fig. 110.

5. **The codlin-moth.** — Secure some apples that have been made wormy by insects of the first brood of codlin-moths. Cut them through the exit hole and the core as shown in Fig. 111. See if you can find apples made wormy by the larvæ of the second brood and determine the route taken by the worms.

During a field trip search for cocoons of the codlin-moth. They may often be found on the under side of the bark of apple trees. Compare the number of windfalls under sprayed and unsprayed apple trees.

6. **The peach-tree borer.** — During the month of May visit a near-by peach orchard and look for borers. Dig the earth away from the base of the tree to a depth of six to eight inches and, whenever a borer is found, either cut into the burrow with the knife, find the borer, and kill it, or push the piece of wire through the burrow until it strikes the borer and kills it. When using the knife destroy as little bark as possible. Make the cut up and down, not around the tree, to avoid girdling it. When finished with the work place the soil back about the tree to prevent the roots from drying. Visit the orchard again in September or October and kill what borers you find.

7. **Decay in fruit.** — Bruise two apples by striking them on the top of a table. Do not break the skin. Bruise two others by striking them against a sharp corner of the table. Let the skin be broken slightly. Keep the other two as a check. Place all the apples where they will be undisturbed and watch the results. Keep a record of the length of time that occurs before each shows decay.

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CHAPTER XIII

VEGETABLE-GROWING

EVERY home uses vegetables. These vegetables are grown by some person, somewhere. To grow them requires skill, a well equipped establishment, the proper soil and location, knowledge of varieties, ability to control insects and diseases, understanding of the markets and what the people want. In former time, the vegetables were grown at home. Now many or most of them are produced by specialists, who make the growing of them a business. Some of them are raised in fields under glass. The markets are supplied by truck-farmers and market-gardeners, as explained in the third paragraph; yet it is as important as ever that every person having land grow as many of his own vegetables as possible.

A wholesale produce market, about two or three o'clock in the morning, is a remarkable sight. There are products in great variety and immense quantities; gardeners with their loads; commission men displaying the produce; buyers eager for the best bargains; activity everywhere. Usually by five o'clock the market is empty, the produce gone to the shops where it will be sold to families; and the ordinary early riser

passing that way sees little but empty rooms and an uninteresting establishment. One half does not know how the other half lives.

150. Market-gardening and truck-farming. — These terms require some explanation. In market-gardening the growing of vegetables is conducted near the market where they are to be sold. The gardens are near cities on high-priced land and the produce is hauled to market by team or motor truck. Under these conditions the acre returns must be large in order to pay interest on the value of the land and other capital invested. In truck-farming the vegetables are grown on farms somewhat remote from the market and the produce is shipped by train or boat. The land is usually low in value compared with market-gardens and is chosen because of its adaptability to vegetable-growing. Market-gardening and truck-farming often overlap. For example, a market-gardener may at times find it more profitable to ship his produce to a distant market than to sell it near home, or a truck-farmer may find that at times he can develop a home market for at least a portion of his produce.

151. Soils for vegetables. — The best soils for most vegetable crops are sandy or sandy loams. Vegetables usually do well on such soils, if the ground is properly fertilized and otherwise cared for. The soils are easy to work and seldom become sticky; they can be worked soon after a rain; and they are warm. All of these points are important. Vegetable-growing requires that the soil be worked frequently. Sticky soils are to be avoided, as they are not only difficult to get into good tilth, but the particles will adhere to many of the vegetables and may lessen their value. To be able to work a soil soon after a rain is a decided advantage to a gardener. A warm soil is of prime importance in the production of vegetables. If sufficiently watered and fertilized, such a soil will produce vegetables quickly, which tends to make them succulent and of better quality than if they are a long time developing. A

warm soil also means early vegetables, the kind which bring high prices on the market.

Good drainage is necessary. The water-table should be at least a foot and a half below the surface. Often the draining of a piece of light loam will make it very desirable for a vegetable-garden.

152. Kinds of vegetable crops. — Many sorts of vegetables are grown. The number is greater than that of general farm crops. Some vegetables are grown for underground parts, others for the foliage parts, and still others for the seed parts. A classification of vegetables according to the parts used for food adapted from Bailey is given below:

Annual Vegetable Crops

Crops grown for underground parts:

Root crops. — Beet, carrot, celeriac, parsnip, radish, salsify, sweet potato, turnip, rutabaga.

Tuber crop. — Irish potato.

Bulb crops. — Onion, leek, garlic, shallot, chive.

Crops grown for foliage parts:

Cole crops. — Kale, or borecole, Brussels sprouts, cabbage, cauliflower, broccoli, kohlrabi, collard.

Pot-herb crops (greens). — Spinach, chard, beet, dandelion, purslane, mustard, sea kale, turnip (for greens), Swiss chard, rape.

Salad crops. — Lettuce, endive, celery, parsley, cress, upland or winter cress, watercress, corn-salad.

Crops grown for fruit or seed parts:

Pulse crops. — Bean, pea.

Solanaceous crops. — Tomato, eggplant, pepper, husk tomato.

Vine crops. — Cucumber, watermelon, muskmelon, gherkin, pumpkin, squash.

The chief perennial vegetables grown are asparagus, rhubarb, and horse-radish. The first two are used for the foliage and the last for the roots.

153. The farm-garden. — The home-garden of the farm is too often badly neglected. This is unfortunate, because the garden can and should be made an important part of the farm. One of the chief reasons for having a good garden is that it provides healthful food for the family. This should be a matter of much careful consideration. A dairyman feeds beets to his stock primarily for the beneficial effect on their digestive system. In the same way one value of wholesome vegetables consists in helping to keep the body in good physical condition. Good health to the farmer is not only a matter of comfort; it is important from the efficiency standpoint.

Dwellers in the city can secure fresh vegetables every day, because they are in the markets, but the farmer unless he maintains a good garden cannot have them. One usually thinks of the farm as a place where vegetables are always plentiful, but there is no place that suffers more from dearths and over-supplies of vegetables than the farm. This is because the marketable supply goes to the city and there is none left for the farmer, unless he plans his home-garden wisely.

Aside from the matter of health, a farm-garden is a source of economy. It will pay good returns for the time and money spent on it. If the products that can be grown on a farm-garden were purchased, they would amount to a considerable sum each year.

Soils for the farm-garden. — As a general rule, if a sandy or a sandy loam soil is available, it should be chosen for the home-garden. An exception might occur in regions of scant rainfall. Such soils under this condition might dry out so quickly that they would not be suitable for the garden, in which case a soil more retentive of moisture should be used. However, even when the rainfall is scant, a sandy or loamy soil might be used advantageously for early spring crops and another garden of heavier soil be used for later plantings.

Range of crops. — In planning the home-garden, a wider range of vegetables than is usually planted should be provided.

Many vegetables are often better adapted to the soil and climatic condition of other regions than the ones in which they are usually grown.

Hardy vegetables like onions, peas, beets, lettuce, and radishes should be planted early in order that fresh vegetables may be obtained early in the year. These hardy crops will stand considerable cold and, even if some are killed by frost, it is comparatively inexpensive to replant the seeds. Half-hardy and tender crops as cucumbers, melons, and the like, should not be planted until the ground is fairly warm.

Some vegetables remain in good condition for table use only a short time after coming to maturity, while others continue bearing over a relatively long season. Peas, beans, radishes, lettuce, and sweet corn are examples of the former, and tomatoes, cucumbers, and melons of the latter. In the case of the crops that last only a short period, it is well to have a succession of plantings. To plant peas and beans, for example, once a week for four weeks will very much extend the season during which this vegetable is available for use. Sweet corn under New Jersey conditions may be planted from April 15 to July 15, and if several plantings were made during this time, farmers could have fresh sweet corn for a long time during the summer and fall. Those vegetables that remain in good condition for a considerable period do not need to be planted in succession. Another way to extend the season for vegetables is to plant in the late summer those spring-grown crops that will make a growth in the fall. Peas, string beans, lettuce, carrots, and beets are examples. None of these crops will grow, however, if planted in midsummer. In the South the fall garden can be made very important and by the use of coldframes the season for fresh vegetables can be extended well into the winter.

Certain perennial crops should always be found in the farm-garden. These should include bush-fruits and strawberries as well as asparagus, rhubarb, and horse-radish. They should

be grouped along one side to be out of the way of the tillage operations of the portion to be devoted to annuals.

Enriching the soil. — The character of the growth of vegetables is very different from that of general farm crops. Vegetables do not have elaborate root-systems, their period of growth is short, and to be of good quality they must make a rapid growth. Thus it is an advantage to fertilize the garden heavily, more so than for field crops. Annual application of twenty to thirty tons of manure to an acre are often made on garden soils and in addition commercial fertilizer at the rate of a half ton or more to the acre may be used to advantage. After the manure is spread the soil should be plowed to a good depth and harrowed until a fine, mellow seed-bed is made. If the soil is inclined to be sour, apply lime. One hundred pounds of ground limestone to every hundred square feet of area is a usual application. The lime may be spread after the land is plowed and before it is harrowed. Lime and manure or lime and fertilizer should not be applied at the same time, as a chemical action meaning loss of plant-food would result.

Tools for farm-gardening. — It is economy to plant and cultivate gardens with modern tools. A combined seeder and cultivator is a good implement to use. The seeder will plant more cheaply and better than can be done by hand and the same implement with a different attachment will, if used frequently, keep the soil mellow and free from weeds.

For some vegetables the rows may be made wide and horse-power used to cultivate the garden, but in the case of others, string beans and peas, for example, too wide planting is not advisable as the weeds are not easily kept down unless the plants shade the ground between the rows.

154. Planting-table for vegetables.—A very complete planting-table for vegetables for conditions both in the North and the South is given in Table IV, pages 284–5. This will be especially handy for reference.

QUESTIONS

1. In general what are the differences between market-gardening and truck-farming?
2. What kinds of soil are best for vegetables? Why?
3. Why should a farmer have a good home-garden?
4. For what reasons should a wide range of crops be grown in the home-garden?
5. Name some hardy vegetables that can be planted early.
6. Why do vegetables require large quantities of fertilizer?
7. State the advantages of using modern tools in caring for a garden?
8. Why is too wide planting not advisable for some vegetable crops?

EXERCISES

1. **Farm-garden.** — Plan a garden for your own farm, taking into consideration vegetables for spring and fall planting, the arrangement in the garden, the methods of planting, the quantity of seed required, when each lot of seed should be planted, and other similar matters.

2. **Method of growing cucumbers.** — This method of growing cucumbers is applicable especially to a small garden. The equipment required is a sugar barrel, a quantity of manure, cucumber seeds, a brace and one-inch bit, a hammer, nails, and a short strip of wood.

Remove the top from the barrel and bore three one-inch holes in each stave, spacing them about six inches apart. Bore the first hole six inches from the bottom. Nail the pieces of the head together with the strip of wood to form a cover for the barrel. Dig a hole in a fertile spot in a garden and place the barrel in this hole so that about half the barrel is above the level of the ground. Fill the barrel with manure. Make a mound of fertile soil around the sides of the barrel, extending to within six inches of the top. The soil should be about twenty inches thick at the base. Plant six or eight hills of cucumbers in the mound of soil around the barrel, placing eight or ten seeds an inch deep in each hill.

Pour water on the manure in the barrel each day. This forms a liquid fertilizer that will pass through the holes of the staves and furnish plant-food and moisture to the cucumbers. Keep the cover on the barrel, except when watering the plants. Flies will breed rapidly in the manure unless the barrel is kept covered. As soon as the plants start to run to vine, remove all but the best three or four in each hill. This will leave more fertility and moisture for the others. Carefully

TABLE IV

PLANTING-TABLE FOR VEGETABLES

Quantity of seeds or number of plants required for a row 100 feet in length, with distances to plant, times for planting, and period required for production of crop

Brackets indicate that a late or second crop may be planted the same season

KIND OF VEGETABLE	SEEDS OR PLANTS REQUIRED FOR 100 FEET OF ROW	DISTANCE FOR PLANTS TO STAND			DEPTH OF PLANTING	TIME OF PLANTING IN OPEN GROUND		READY FOR USE AFTER PLANTING
		Rows apart		Plants apart in rows		South	North	
		Horse cultivation	Hand cultivation					
Artichoke, Globe	½ ounce	3 to 4 ft.	2 to 3 ft.	2 to 3 ft.	1 to 2 in.	Spring	Early spring	15 months
Artichoke, Jerusalem	2 qt. tubers	3 to 4 ft.	1 to 2 ft.	1 to 2 ft.	2 to 3 in.	Spring	Early spring	6 to 8 months
Asparagus, seed	1 ounce	30 to 36 in.	1 to 2 ft.	3 to 5 in.	1 to 2 in.	Autumn or early spring	Early spring	3 to 4 years
Asparagus, plants	60 to 80 plants	3 to 5 ft.	12 to 24 in.	15 to 20 in.	3 to 5 in.	Autumn or early spring	Early spring	1 to 3 years
Beans, bush	1 pint	30 to 36 in.	18 to 24 in.	5 or 8 to ft.	½ to 2 in.	February to April. [August to September.]	April to July	40 to 65 days
Beans, pole	½ pint	3 to 4 ft.	3 to 4 ft.	3 to 4 ft.	1 to 2 in.	Late spring	May and June	50 to 80 days
Beets	2 ounces	24 to 36 in.	12 to 18 in.	5 or 6 to ft.	1 to 2 in.	February to April. [August to September.]	April to August	60 to 80 days
Brussels sprouts	¼ ounce	30 to 36 in.	24 to 30 in.	16 to 24 in.	½ in.	January to July	May and June	90 to 120 days
Cabbage, early	¼ ounce	30 to 36 in.	24 to 30 in.	12 to 18 in.	½ in.	October to December	March and April. (Start in hot-bed during February.)	90 to 130 days
Cabbage, late	¼ ounce	30 to 40 in.	24 to 36 in.	16 to 24 in.	½ in.	June and July	May and June	90 to 130 days
Cardoon	½ ounce	3 ft.	2 ft.	12 to 18 in.	1 to 2 in.	Early spring	April and May	5 to 6 months
Carrot	1 ounce	30 to 36 in.	18 to 24 in.	6 or 7 to ft.	½ in.	March and April. [September.]	April to June	75 to 110 days
Cauliflower	¼ ounce	30 to 36 in.	24 to 30 in.	14 to 18 in.	½ in.	January and February. [June.]	April to June. (Start in hot-bed during February or March.)	100 to 130 days
Celeriac	¼ ounce	30 to 36 in.	18 to 24 in.	4 or 5 to ft.	⅛ in.	Late spring	May and June. (Start in cold frame during April.)	100 to 150 days
Celery	¼ ounce	3 to 6 ft.	18 to 36 in.	4 to 8 in.	⅛ in.	August to October	May and June. (Start in hot-bed or cold frame during March or April.)	120 to 150 days
Chervil	1 ounce	30 to 36 in.	18 to 24 in.	3 or 4 to ft.	1 in.	Autumn	Autumn	1 year
Chicory	¼ ounce	30 to 36 in.	18 to 24 in.	4 or 5 to ft.	½ in.	March and April	May and June	5 to 6 months
Citron	1 ounce	8 to 10 ft.	8 to 10 ft.	8 to 10 ft.	1 to 2 in.	March and April	May and June	100 to 130 days
Collards	¼ ounce	30 to 36 in.	24 to 30 in.	14 to 18 in.	½ in.	May and June	Late spring	100 to 120 days
Corn salad	2 ounces	30 in.	12 to 18 in.	5 or 6 to ft.	½ to 1 in.	January and February. [September and October.]	March to September	60 days
Corn, sweet	¼ pint	36 to 42 in.	30 to 36 in.	30 to 36 in.	1 to 2 in.	February to April	May to July	60 to 100 days
Cress, upland	½ ounce	30 in.	12 to 18 in.	4 or 5 to ft.	⅛ to 1 in.	January and February. [Autumn.]	March to May. [September.]	30 to 40 days
Cress, water	½ ounce	Broadcast	—	—	On surface	Early spring	April to September	60 to 70 days

Cucumber	½ ounce	4 to 6 ft.	4 to 6 ft.	4 to 6 ft.	1 to 2 in.	February and March. [September.]	April to July	60 to 80 days
Dandelion	¼ ounce	30 in.	18 to 21 in.	8 to 12 in.	½ in.	Early spring or autumn	Early spring	6 to 12 months
Eggplant	⅛ ounce	30 to 36 in.	24 to 30 in.	18 to 24 in.	½ to 1 in.	February to April	April and May. (Start in hot-bed during March.)	100 to 140 days
Endive	1 ounce	30 in.	18 in.	8 to 12 in.	½ to 1 in.	February to April	April. [July.]	90 to 180 days
Horse-radish . . .	70 roots	30 to 40 in.	24 to 30 in.	14 to 20 in.	3 to 4 in.	Early spring	Early spring	1 to 2 years
Kale, or borecole .	¼ ounce	30 to 36 in.	18 to 24 in.	18 to 24 in.	½ in.	October to February	August and September. [March and April.]	90 to 120 days
Kohlrabi	¼ ounce	30 to 36 in.	18 to 24 in.	4 to 8 in.	½ in.	September to March	March to May	60 to 80 days
Leek	⅛ ounce	30 to 36 in.	14 to 20 in.	4 to 8 in.	1 in.	May to September	March to May	120 to 180 days
Lettuce	⅛ ounce	30 in.	12 to 18 in.	4 to 6 in.	½ in.	September to March	March to September	60 to 90 days.
Melon, muskmelon	½ ounce	6 to 8 ft.	6 to 8 ft.	Hills 6 ft.	1 to 2 in.	February to April	April to June. (Start early plants in hot-bed during March.)	120 to 150 days
Melon, watermelon	1 ounce	8 to 12 ft.	8 to 12 ft.	Hills 10 ft.	1 to 2 in.	March to May	May and June	100 to 120 days
Mustard	¼ ounce	30 to 36 in.	12 to 18 in.	4 or 5 to ft.	¼ in.	Autumn or early spring	March to May. [September.]	60 to 90 days.
New Zealand spinach	1 ounce	36 in.	24 to 36 in.	12 to 18 in.	1 to 2 in.	Early spring	Early spring	60 to 100 days
Okra, or gumbo . .	2 ounces	4 to 5 ft.	3 to 4 ft.	24 to 30 in.	1 to 2 in.	February to April	May and June	90 to 140 days
Onion, seed . . .	1 ounce	24 to 36 in.	12 to 18 in.	4 or 5 to ft.	½ to 1 in.	October to March	April and May	130 to 150 days
Onion, sets . . .	1 quart of sets	24 to 36 in.	12 to 18 in.	4 or 5 to ft.	1 to 2 in.	Early spring	Autumn and February to May	90 to 120 days
Parsley	¼ ounce	24 to 36 in.	12 to 18 in.	3 to 6 in.	½ in.	September to May	September and early spring	90 to 120 days
Parsnip	½ ounce	30 to 36 in.	18 to 24 in.	5 or 6 to ft.	½ to 1 in.	—	April and May	125 to 160 days
Peas	1 to 2 pints	3 to 4 ft.	30 to 36 in.	15 to ft.	2 to 3 in.	September to April	March to June	40 to 80 days
Pepper	⅛ ounce	30 to 36 in.	18 to 24 in.	15 to 18 in.	½ in.	Early spring	May and June. (Start early plants in hot-bed during March.)	100 to 140 days
Physalis	⅛ ounce	30 to 36 in.	18 to 24 in.	18 to 24 in.	½ in.	March to May	May and June	130 to 160 days
Potato, Irish . . .	5 lb. (or 9 bu. per acre)	30 to 36 in.	24 to 36 in.	14 to 18 in.	4 in.	January to April	March to June	80 to 140 days
Potato, sweet . .	3 lb. (or 75 slips)	3 to 5 ft.	3 to 5 ft.	14 in.	3 in.	April and May	May and June. (Start plants in hot-bed during April.)	140 to 160 days
Pumpkin	½ ounce	8 to 12 ft.	8 to 12 ft.	Hills 8 to 12 ft.	1 to 2 in.	April and May	May to July	100 to 140 days
Radish	1 ounce	24 to 36 in.	12 to 18 in.	8 to 12 to ft.	½ to 1 in.	September to April	March to September	20 to 40 days
Rhubarb, seed . .	½ ounce	36 in.	30 to 36 in.	6 to 8 in.	½ to 1 in.	—	Early spring	2 to 4 years
Rhubarb, plants .	33 plants	3 to 5 ft.	3 to 5 ft.	3 ft.	2 to 3 in.	—	Autumn or early spring	1 to 3 years
Rutabaga . . .	¼ ounce	30 to 36 in.	18 to 24 in.	6 to 8 in.	½ to 1 in.	August and September	May and June	60 to 80 days
Salsify	1 ounce	30 to 36 in.	18 to 24 in.	2 to 4 in.	½ to 1 in.	Early spring	Early spring	120 to 180 days
Spinach	1 ounce	30 to 36 in.	12 to 18 in.	7 or 8 to ft.	1 to 2 in.	September to February	September or very early spring	30 to 60 days
Squash, bush . .	½ ounce	3 to 4 ft.	3 to 4 ft.	Hills 3 to 4 ft.	1 to 2 in.	Spring	April to June	60 to 80 days
Squash, late . . .	½ ounce	7 to 10 ft.	7 to 10 ft.	Hills 7 to 9 ft.	1 to 2 in.	Spring	April to June	120 to 160 days
Tomato	⅛ ounce	3 to 5 ft.	3 to 4 ft.	3 ft.	½ to 1 in.	December to March	May and June. (Start early plants in hot-bed during February and March.)	100 to 140 days
Turnip	½ ounce	24 to 36 in.	18 to 24 in.	6 or 7 to ft.	¼ to ½ in.	August to October	April. [July.]	60 to 80 days
Vegetable marrow .	½ ounce	8 to 12 ft.	8 to 12 ft.	Hills 8 to 9 ft.	1 to 2 in.	Spring	April to June	110 to 140 days

weed and cultivate the soil of the mound of earth at frequent intervals during the growing season, and an excellent crop of cucumbers should be harvested. Keep a record of the cost of labor, materials, and yield.

Grow the same number of hills of cucumbers in the garden in the usual way without special attention to plant-food and moisture and contrast the results with those of the cucumbers grown around the barrel.

3. **Forcing crops of rhubarb.** — In the spring, crops of rhubarb can be much hastened by artificially heating the plants in the following way: Place an inverted half barrel over the clump of plants and pile manure on top and on the sides of the barrel. The heat from the manure will cause early growth. Leave a few clumps of rhubarb uncovered and contrast the growth in the two lots. Why do the rhubarb stalks under the barrel grow somewhat spindling? Why is there a difference in color between the covered and the uncovered plants?

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CHAPTER XIV

FEEDING FARM ANIMALS

Importance of animal feeding.
Functions of feed.
Balanced rations.
Kinds of feeds.
Palatability of feed.
Effect of feed on the digestion.
Cost of feed.
Suiting the feed to the animal.
Digestibility of feed.

WE have learned that we cannot expect good crops unless we provide the plants the proper kinds and quantities of food materials. Similarly we cannot hope to have the best domestic animals, or to secure the heaviest yields from them, unless we learn how to feed them. The feeding of animals has now come to be a complex subject, due to the greater knowledge we have secured, the attempt to use many new kinds of feed, and the necessity of obtaining surer results. The principles of feeding are not difficult to understand, however, and we are now about to discuss them and to learn how to make some of the applications to practice.

155. Importance of animal feeding. — The feeding of farm animals is an important part of animal husbandry. Many feeders who know only the art of feeding are successful, but when a man is found who knows both the art and the science of the work, he usually is doubly successful. The principles on which the feeding of farm animals is based deal with such factors as the composition of the various feed stuffs, the digestion and absorption of the feed, the quantity and kind of feed

required by different classes of animals, whether or not the feeds are palatable to the animals, and their cost and availability.

156. Functions of feed. — When taken into the animal body and digested and absorbed, feed performs certain functions. In the first place it creates energy that is used in moving the body about, in heating the body, in carrying blood through the circulatory system, in moving the food through the alimentary canal, and the like. In addition, energy is required to produce the changes that are going on in the cells of the body. The feed also builds up the tissues of the body and secretes the fluids necessary for the life processes. Tissues are constantly wearing out and must be replaced.

The water, ash, carbohydrates, protein, and fat all have their uses when taken into the animal body. Water is contained in every kind of living tissue and none of the life processes can be carried on without it. The body of an animal is about 50 per cent water and the fluids range from 90 to 99 per cent water. As in plants, water is the means by which the food is carried from place to place in the body. Water also helps to keep the temperature normal.

Ash is used largely to furnish mineral matter for the bones. In the case of hens it furnishes the material for the egg-shells. A certain amount of ash is found in all tissue.

Lean meat, or muscle, blood, skin, hair, hoofs, and vital organs are largely protein. As these tissues are made out of the protein of the feed, it is readily seen why the proper quantity of protein in the feed is so necessary. If there is in the feed more than enough protein to supply that needed in building up the lean meat and other tissues, the surplus goes to make energy. As energy can be produced more cheaply by the use of carbohydrates and fats, it is not profitable to have feeds contain a larger proportion of protein than is necessary.

The carbohydrates produce energy and heat and build up the fat of the body. Therefore, feeds rich in carbohydrates, such as corn, are fattening.

Fat, when taken into the body as feed, acts the same as carbohydrates; that is, it produces heat and energy and makes fat. A given quantity of fat will produce about two and a quarter times as much heat and energy as the same quantity of carbohydrates.

157. Balanced rations. — The term ration is used to indicate the quantity of feed supplied to an animal in a given time. A balanced ration is one that supplies all the constituents in the best proportion to serve the needs of the animal for the purpose for which it is kept. For example, a balanced ration for a dairy cow contains the food compounds necessary to maintain life and to make it possible to produce milk up to the limit. Experiments and practical tests have shown that animals will do more work and more profitably when fed a balanced ration than when fed an unbalanced one.

The terms maintenance ration and productive ration are used in connection with animal feeding. A maintenance ration is one that supplies the needs of an animal at rest with no loss or gain of weight. A productive ration is one that supplies the needs of the animal in excess of maintenance and makes possible a production of milk, a gain in weight, or power to pull a load, and the like. The terms nutritive ratio, wide ratio, and narrow ratio, also need defining. The nutritive ratio is that of the digestible protein in a feed or ration to the digestible carbohydrates and fat. (See paragraph 163.) To compute the nutritive ratio of a feed or ration, the amount of the digestible fat is multiplied by $2\frac{1}{4}$ and added to the amount of the digestible carbohydrates and the sum divided by the amount of the digestible protein. The ratio is expressed as 1 to the quotient. For example, suppose a ration furnished 2.6 pounds of digestible protein, 13 pounds of digestible carbohydrates, and .6 pound of fat; the nutritive ratio is calculated as follows:

$$(.6 \times 2\tfrac{1}{4} + 13) \div 2.6 = 5.5 +$$

The nutritive ratio is, therefore, 1 : 5.5.

A wide nutritive ratio is one in which the relative proportion of protein is small and the carbohydrates large. A narrow nutritive ratio is one in which the protein is large and the carbohydrates small. In practice a ratio of 1 : 5 or less is said to be narrow; one from 1 : 5 to 1 : 8 medium, and one larger than 1 : 8 wide.

158. Kinds of feeds. — Feeds may be grouped as concentrates and roughage. Concentrates are those that yield a large proportion of digestible nutrients. They include the grains, seeds, and by-products. The grains are rich in carbohydrates and rather poor in protein, as shown by the analyses given in Table V.

TABLE V

COMPOSITION OF GRAINS

FEED	Composition					
	Water %	Ash %	Protein %	Carbohydrates: Fiber %	Carbohydrates: Nitrogen-free Extract %	Fat %
Corn, grain	10.6	1.5	10.3	2.2	70.4	5.
Wheat, grain	10.5	1.8	11.9	1.8	71.9	2.1
Oats, grain	10.4	3.2	11.4	10.8	59.4	4.8
Barley, grain	10.8	2.5	12.0	4.2	68.7	1.8
Rye, grain	8.7	2.1	11.3	1.5	74.5	1.9

NOTE. — This and the succeeding tabulations of the compositions of feed stuffs are from a pamphlet entitled "Principles of Animal Feeding," published by the International Textbook Co.

Most by-product feeds are rich in protein and poor in carbohydrates. They are much used with the grains in securing a proper balance of the concentrates of a ration. In Table VI are given the analyses of some of the most common by-product feeds arranged in order of the proportion of protein that they contain.

TABLE VI

COMPOSITION OF BY-PRODUCT FEEDS

Feed	Composition					
	Water %	Ash %	Protein %	Carbohydrates: Fiber %	Carbohydrates: Nitrogen-free Extract %	Fat %
Hominy feed	9.6	2.7	10.5	4.9	64.3	8.0
Corn bran	9.4	1.2	11.2	11.9	60.1	6.2
Rye middlings	11.8	1.7	14.3	2.4	66.9	2.9
Rye bran	11.8	3.4	14.6	3.5	63.9	2.8
Wheat bran	11.9	5.8	15.4	9.0	53.9	4.0
Shorts	11.2	4.4	16.9	6.2	56.2	5.1
Germ oil meal	8.6	2.4	21.7	8.8	47.3	11.2
Dried brewers' grains	8.7	3.7	25.0	13.6	42.3	6.7
Gluten feed	9.2	2.0	25.0	6.8	53.5	3.5
Malt sprouts	9.5	6.1	26.3	11.6	44.9	1.6
Dried distillers' grains	7.6	2.0	31.2	11.6	35.4	12.2
Gluten meal	9.5	1.5	33.8	2.0	46.2	6.6
Old process linseed meal	9.8	5.5	33.9	7.3	35.7	7.8
New process linseed meal	9.7	5.5	37.5	8.9	36.4	2.0
Cottonseed meal	7.0	6.6	45.3	6.3	24.6	10.2
Tankage	7.0	15.9	53.9	5.8	5.6	11.8
Dried blood	8.5	4.7	84.4	—	—	2.5

Roughage feeds are those of a bulky nature. They may be either dry or succulent. The hays, straws, and fodders are dry roughages and silage, roots, pasturages, and soiling crops are succulent. Roughages contain a large proportion of crude fiber and are less digestible than the concentrates. They are of value, however, for a certain quantity of bulk must be in the feed to aid digestion. Some classes of animals require more bulky feeds than others. For example a dairy cow must have more bulk in her feed than a horse requires.

Hay is the most valuable dry roughage. Hays may be classed as leguminous and non-leguminous. Since leguminous hays are richer in protein than hay from grasses, less protein

in the form of concentrates is necessary. Leguminous hays are especially valuable for dairy cows; alfalfa, clover, cowpea, and soybean hays are largely used in rations for dairy cattle. Table VII gives analyses of some of the leading hays.

TABLE VII

COMPOSITION OF HAYS

Feed	Composition					
	Water %	Ash %	Protein %	Carbohydrates		Fat %
				Fiber %	Nitrogen-free Extract %	
Alfalfa	6.6	9.0	15.8	30.2	35.8	1.9
Cowpea hay	10.5	14.2	8.9	21.2	42.6	2.6
Soybean hay	11.8	7.0	14.9	24.2	37.8	4.3
Red clover hay	15.3	6.2	12.3	24.8	38.1	3.3
Crimson clover hay	9.6	8.6	15.2	27.2	36.6	2.8
Japan clover hay	11.0	8.5	13.8	24.0	39.0	3.7
Bur clover hay	9.0	5.0	13.6	30.6	38.2	3.6
Timothy hay	13.2	4.4	5.9	29.0	45.0	2.5
Barley hay	5.5	4.2	8.8	24.7	44.9	2.4
Oat hay	14.4	5.7	8.9	27.4	41.2	2.8
Redtop hay	8.7	4.9	8.0	29.9	46.4	2.1
Rye hay	9.5	5.7	10.8	32.6	38.7	2.7
Mixed grasses hay	15.3	5.5	7.4	27.2	42.1	2.5
Mixed grasses and clover hay	12.9	5.5	10.1	27.6	41.3	2.6

The straws are very high in crude fiber. Nevertheless they are of some value as feed. Horses doing no work or dry cows are sometimes given straw as a part of their rations, as they do not need roughages containing richer feed materials. In the analyses given in Table VIII the relatively small percentages of nitrogen-free extract and protein and the high percentages of fiber should be compared with the analyses previously given.

TABLE VIII

COMPOSITION OF STRAWS AND CORN STOVER

FEED	Composition					
	Water %	Ash %	Protein %	Carbohydrates		Fat %
				Fiber %	Nitrogen-free Extract %	
Wheat straw	9.6	4.2	3.4	38.1	43.4	1.3
Oat straw	9.2	5.1	4.0	38.1	42.4	2.3
Rye straw	7.1	3.2	3.0	38.9	46.6	1.2
Barley straw	14.2	5.7	3.5	36.0	39.0	1.5
Corn fodder	42.4	2.7	4.5	14.3	34.7	1.6
Corn stover	40.5	3.4	3.8	19.7	31.7	1.1

Fodders and stovers come principally from the corn plant. Corn fodder is the whole mature dried plant. Corn stover is the mature dried plant minus the ears. They compare with the grass hays in analyses. Often the fodder or the stover is shredded before it is fed. This prepares it in better form for feeding than if left whole. Fodder is often fed to fattening steers, but for dairy cows it is less desirable. Corn stover is sometimes used as a maintenance ration for keeping steers over the winter, but it is not especially desirable when large quantities are fed. The analyses of the two feeds are given in Table VIII.

The succulent roughages contain a large proportion of water and are very valuable for this reason. Pasturage forms practically a balanced ration for dairy cattle, sheep, and horses; often they are given no other feed. Hard-worked animals should, however, receive some supplement to pasturage.

Silage, soiling crops, and root crops are fed extensively to dairy cows, since a large quantity of succulence is necessary for animals in milk flow. Succulence not only aids in milk

flow, but helps to keep the bowels in a lax condition, which is essential to high production of milk. The analyses of a few of the most used succulent feeds are given in Table IX.

TABLE IX

COMPOSITION OF GREEN CROPS

FEED (Green)	Composition					
	Water %	Ash %	Protein %	Carbohydrates		Fat %
				Fiber %	Nitrogen-free Extract %	
Alfalfa	71.8	2.7	4.8	7.4	12.3	1.0
Silage corn	73.6	2.1	2.7	7.8	12.9	0.9
Corn	79.3	1.2	1.8	5.0	12.0	0.5
Crimson clover	80.9	1.7	3.1	5.2	8.4	0.7
Common millet	80.0	1.0	1.5	6.5	10.5	0.5
Pasture grass	80.0	2.0	3.5	4.0	9.7	0.8
Peas and oats	79.7	1.6	2.4	6.1	9.6	0.6
Red clover	70.8	2.1	4.4	8.1	13.5	1.1
Sorghum	79.4	1.1	1.3	6.1	11.6	0.5
Soybeans	75.1	2.6	4.0	6.7	10.6	1.0
Sugar-beets	86.5	0.9	1.8	0.9	9.8	0.1
Carrots	88.6	1.0	1.1	1.3	7.6	0.4
Mangels	90.9	1.1	1.4	0.9	5.5	0.2
Rutabagas	88.6	1.2	1.2	1.3	7.5	0.2
Turnips	90.1	0.9	1.3	1.2	6.3	0.2

159. Palatability of feed. — Feed must be eaten with relish to give the best results. If a ration is not palatable, an animal will not eat it in sufficient quantities to make for productiveness. A mixture of feeds is often more palatable to an animal than one feed; a little more succulence in the ration often causes the animal to eat with a greater relish; the substitution of one kind of mill feed for another is often an advantage. Moldy feed is not relished by animals and often it may cause

sickness or death. The keeping of feed boxes clean is a good way to increase the palatability of the ration.

160. Effect of feed on the digestion. — Another factor that must be considered is the effect of the feed on the digestive system of the animal. Some feeds are laxative in character; others are constipating. Succulent feeds are laxative, so also are linseed meal and wheat bran; corn stover and timothy hay are somewhat constipating to cattle and for this reason dairymen often avoid them; cottonseed meal is also constipating if fed in too large quantities.

161. Cost of feed. — If the farmer is a good business man, he will consider the cost item carefully. As a rule home-grown feeds are cheaper than purchased ones and progressive farmers make use of them whenever possible. Growing a leguminous hay and including it in the ration will often make it possible to cut down on the quantity of by-product concentrates necessary. At times it may pay to sell certain feeds and buy others to take their places. In figuring the cost of feeds, the cost of the protein determines largely the choice of feeds. This is especially true in the West.

162. Suiting the feed to the animal. — Timothy hay is very good for horses, but is not suited to dairy cattle. Red clover hay, although richer in protein than timothy, is not so often fed to horses, as it is likely to be dusty. Dairy cattle, on the other hand, are fed red clover hay in preference to timothy.

163. Digestibility of feed. — A part of the food that is taken into the alimentary tract is not digested and passes from the body as waste matter. The proportion of the food digested depends on the kind, the class of the animal, and the condition of health of the animal. The value of a feed when eaten by an animal depends on how much of it is digested. The term digestible nutrients is used to indicate the portion of the food materials that is digested and absorbed by the animal. Experiments have been made with each kind of feed to determine the proportion of digestible nutrients. The results are not

absolutely accurate, but they are sufficiently so for practical purposes. In Table X is found a tabulation giving the digestible nutrients of the feeds of which the composition is given on previous pages.

TABLE X

DIGESTIBLE NUTRIENTS OF FEEDS

Feed	Total Dry Matter in 100 lb.	Digestible Nutrients in 100 lb.		
		Protein lb.	Carbohydrates lb.	Fat lb.
Corn	89.4	7.8	66.8	4.3
Wheat	89.5	8.8	67.5	1.5
Oats	89.6	10.7	50.3	3.8
Barley	89.2	8.4	65.3	1.6
Rye	91.3	9.5	69.4	1.2
Hominy feed	90.4	6.8	60.5	7.4
Corn bran	90.6	6.0	52.5	4.8
Rye middlings	88.2	11.0	52.9	2.6
Rye bran	88.2	11.2	46.8	1.8
Wheat bran	88.1	11.9	42.0	2.5
Shorts	88.8	13.0	45.7	4.5
Germ oil meal	91.4	15.8	38.8	10.8
Dried brewers' grains	91.3	20.0	32.2	6.0
Gluten meal	90.8	21.3	52.8	2.9
Old process linseed meal	90.2	30.2	32.0	6.9
New process linseed meal	90.3	31.5	35.7	2.4
Cottonseed meal	93.0	37.6	21.4	9.6
Tankage	93.0	50.1	—	11.6
Dried blood	91.5	60.8	—	2.5
Alfalfa hay	93.4	11.4	40.0	1.3
Cowpea hay	89.5	5.8	9.3	1.3
Soybean hay	88.2	10.6	40.9	1.2
Red clover hay	84.7	7.1	37.8	1.8
Japan clover hay	89.0	9.1	37.7	1.4
Bur clover hay	91.0	8.2	39.0	2.1
Timothy hay	86.8	2.8	42.4	1.3
Barley hay	85.0	5.7	43.6	1.0
Oat hay	86.0	4.7	36.7	1.7
Redtop hay	91.1	4.8	46.9	1.0
Mixed grasses and clover hay	87.1	5.8	41.8	1.3
Wheat straw	90.4	0.8	35.2	0.4

TABLE X (*Continued*)

Feed	Total Dry Matter in 100 lb.	Digestible Nutrients in 100 lb.		
		Protein lb.	Carbohydrates lb.	Fat lb.
Oat straw	90.8	1.3	39.5	0.8
Rye straw	92.9	0.7	39.6	0.4
Barley straw	85.8	0.9	40.1	0.6
Corn fodder	57.8	2.5	34.6	1.2
Corn stover	59.5	1.4	31.2	0.7
Alfalfa, green	28.2	3.6	12.1	0.4
Silage, corn	26.4	1.4	14.2	0.7
Corn, green	20.7	1.0	11.9	0.4
Crimson clover, green	19.1	2.4	9.1	0.5
Common millet, green	20.0	0.8	11.0	0.2
Pasture grass	20.0	2.5	10.1	0.5
Red clover, green	29.2	2.9	14.9	0.5
Sorghum, green	20.6	0.6	11.6	0.3
Soybeans, green	24.9	3.1	11.0	0.7
Sugar-beets	13.5	1.3	9.8	0.1
Carrots	11.4	0.8	7.7	0.3
Mangels	9.1	1.0	5.5	0.2
Rutabagas	11.4	1.0	8.1	0.2

QUESTIONS

1. What are the functions of feed when digested and absorbed by an animal?
2. Of what use is the water in a feed?
3. Why is it not economy to supply an excess of protein in feed?
4. What is meant by the term balanced ration?
5. Define maintenance ration, productive ration, nutritive ratio.
6. What is the nutritive ratio of a ration that contains 2.8 pounds of digestible protein, 14 pounds of digestible carbohydrates, and .6 pound of fat?
7. Find the nutritive ratio of the following feeds according to the analyses of the digestible nutrients given in Table X: corn, wheat, oats, wheat bran, cottonseed meal, alfalfa hay, timothy hay, wheat straw, pasture grass, mangels.
8. Make a list of feeds rich in protein and one of feeds low in protein.

9. Why should the concentrates of a ration be richer in protein if timothy hay is fed as the roughage than if alfalfa hay is fed?

10. Why are silage, soiling crops, and roots fed extensively to dairy cows?

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CHAPTER XV

HORSES

Types of horses.
  Draft, heavy-harness, light-harness, saddle, ponies.
The draft breeds.
  Percheron, Clydesdale, Shire, Belgian, Suffolk.
The heavy-harness breeds.
  Hackney, French Coach, German Coach, Cleveland Bay.
The light-harness breed:
  Standard-bred.
The saddle-horse breeds.
  Thoroughbred, American saddlers, Arabian.
Ponies.
  Shetland, Welsh, Hackney, Bronchos and Indian ponies.
Market classes of horses and mules.
Breaking and training colts.
  Teaching the colt to stand tied.
  Gentling the colt.
  Teaching the colt to lead.
  Handling the feet of the colt.
  Teaching the colt the commands used in driving.
  Driving in double harness.
  Driving in single harness.
  Breaking the colt to ride.
Feeds for horses.
Time to water horses.
Soundness in horses.
Determining age of horses.

It is often said that the horse will soon pass away as a farm animal because of the automobile, motor-truck, and tractor. This is an error. Much of the farm work can never be performed economically by mechanical power. There are a thousand uses for horses for which it would not be worth while to invent power machinery. The money value of horses is

increasing, at the same time that the use of automobiles is increasing. This is specially true of heavy horses. The raising of colts as an adjunct to other farm business is a good practice. Mares are therefore particularly desirable as farm horses.

In the South the mule is in more favor for farm work than the horse. He stands the heat, is adapted to rough conditions, and is better handled by colored labor.

164. Types. — Horses may be grouped as draft, heavy-harness, light-harness, saddle horses, and ponies. A brief description of each of these types follows.

The points of the horse are shown in Fig. 118. The location of these points should be learned, as they will be helpful in understanding the descriptions that follow.

Draft horses. — Those horses used for pulling heavy loads are known as draft horses. They are broad, deep, low-set, and massive, ranging in weight from 1600 to 2500 pounds. Those that weigh less than 1600 pounds are known on the market as chunks. Draft horses range in height from 15 to 17 hands.[1]

A broad, deep, compact body set on rather short legs is the general conformation of a draft horse. The head should lack coarseness, the forehead should be broad with good width between the eyes, the neck of moderate length, and neatly fitted to the shoulders, which should be obliquely set and of good length. The back should be fairly short, the chest, deep and broad, the coupling short, the ribs well sprung, the croup should be straight and of moderate length. The hind legs should be well placed, the thighs and quarters well muscled, the hocks clean, the pasterns sloping, and the feet large and sound. In action the horse should show snap and vigor, especially in the walk, and the stride should be long and regular.

[1] Height in horses is measured from the ground to the top of the withers. The unit of measurement is a hand, or 4 inches. A height of 15–3 hands means 15 hands and 3 inches.

Heavy-harness horses. — The show horses of the parks are classed as heavy-harness horses. They are known, also, as coach, or carriage, horses. The weight varies somewhat according to the breed; mares and geldings range from 1100 to

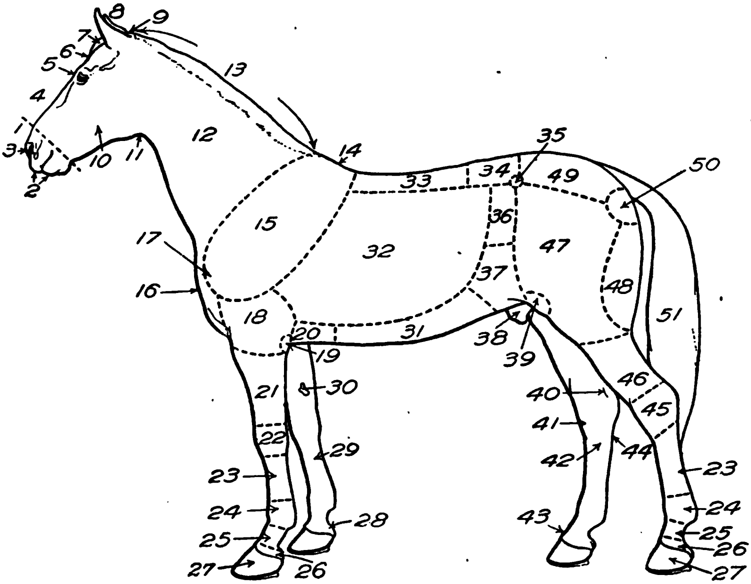

FIG. 118. — Points of the horse. 1, muzzle; 2, lips; 3, nostril; 4, face; 5, eye; 6, forehead; 7, foretop; 8, ears; 9, poll; 10, jaw; 11, throatlatch; 12, neck; 13, crest; 14, withers; 15, shoulder; 16, breast; 17, point of shoulder; 18, arm; 19, elbow; 20, fore flank; 21, forearm; 22, knee; 23, cannon; 24, fetlock joint; 25, pastern; 26, coronet; 27, feet; 28, seat of side bone; 29, seat of splint; 30, chestnut; 31, abdomen; 32, ribs; 33, back; 34, loin; 35, point of hip; 36, coupling; 37, hind flank; 38, sheath; 39, stifle joint; 40, seat of thoroughpin; 41, seat of bog spavin; 42, seat of bone spavin; 43, seat of ring bone; 44, seat of curb; 45, hock; 46, gaskin; 47, thigh; 48, quarter; 49, croup; 50, point of buttock; 51, tail.

1250 pounds and stallions from 1250 to 1450 pounds. The typical coach horse stands about 16 hands high. The animals are less angular than the light-harness horses, next described, and show less speed. The head should be lean,

the neck somewhat arched, the shoulders long and sloping, the body round with a broad back, the croup long and level with heavy muscling, the pasterns sloping, and the feet of fair size. Quality and action are of prime importance. The bone must be of good texture, the hair fine and silky, the skin soft and smooth, and the muscles and veins prominent. The action should be smooth and high, good knee and hock action being especially desirable.

Light-harness horses. — Both roadsters and speed horses are included in the light-harness horse class. Roadsters have endurance, good speed on the road, and are well adapted for drawing light vehicles. As a type they are less uniform than any of the others. A typical one, however, weighs about 1000 pounds and stands from 15–1 to 15–3 hands high. The muscles should be prominent and the form decidedly angular. The head should be lean and refined, the neck slender and of good length, and the shoulders sloping. The body is usually rather closely coupled and shows heavy muscles over the loins. The bone should be fine in texture, the hair fine and glossy, and the skin soft; these indications of quality are essential. The pasterns should slope at an angle of about 45 degrees with the ground, be of good length, and show elasticity. The stride should be straight and long. Speed on the road is of prime importance.

Speed horses driven in harness include both trotters and pacers and they have the general conformation of roadsters. Endurance and speed on the race track in such horses are, of course, especially necessary.

Saddle horses. — Horses of the saddle type are used for pleasure riding, racing, and hunting. They range in height from 14 to 16 hands and in weight from about 850 to 1050 pounds. A saddle horse should be sure-footed, an easy-rider, and easily controlled. In conformation it should have oblique shoulders and pasterns to give spring to the action; high, thin withers to prevent the saddle from turning; and a short back

and short loins to give strength for carrying the weight of the rider.

Sub-classes of saddle horses according to action are five-gaited and three-gaited animals. Five-gaited saddlers must possess five gaits — walk, trot, canter, singlefoot, or rack, and a slow gait which may be either the running walk, fox-trot, or slow pace. Three-gaited saddlers have the three gaits — walk, trot, and canter.

The canter is a slow gallop. The rack is a rather fast gait in which each foot hits the ground at a different time. It is often called the singlefoot gait. The running walk is a slow singlefoot that is intermediate in speed between the walk and the rack. The fox-trot is a short broken gait in which the front legs go at a trot and the hind legs at a modified pace. The slow pace is a saddle gait in which the horse paces at slow speed, but does not show much side motion.

Ponies. — A pony is any horse, regardless of type of breed, under 14–2 hands in height. At the horse shows, they are usually grouped into three classes: (1) under 46 inches high; (2) 12–2 to 14–2 hands; (3) polo ponies.

165. The draft breeds. — Percheron, Clydesdale, Shire, Belgian, and Suffolk are the draft breeds of horses found in the United States. A brief description of each breed is given on the next few pages.

Percheron. — The most popular draft horse in the United States is the Percheron (Fig. 119). More horses of this breed are registered as pure-bred animals than of all the other draft breeds combined. The breed derives its name from the district of La Perche in northwestern France. The exact origin of the breed is somewhat obscure, but according to most authorities it was developed by the crossing of native mares and Arabian stallions that were brought to the district in 1820 by the French government. Percherons range in height from 15–3 to 17 hands and in weight from 1600 to 2300 pounds. As a rule they show a little less weight than the

Belgians or the Shires, but more than Clydes or Suffolks. The Percheron is of the true draft form. Feather, or the long hair about the fetlocks, is not found in the animals of this breed. The head is refined in appearance, with good width between the eyes; the ears are rather small and are carried erect; the neck is of moderate length and shows less arch than is found in some of the other draft breeds. The action is true, strong, and snappy. The usual colors are gray and black, but often bay, brown, and chestnut are found.

FIG. 119. — Percheron stallion.

Clydesdale.—The native home of the Clydesdale (Fig. 120) is in the County Lanack in the Valley of the Clyde, Scotland. Clydesdales range in height from 16 to 17 hands and in weight from 1800 to 2200 pounds. Compared with Percherons, they are somewhat longer of

FIG. 120. — Clydesdale stallion.

leg and lighter and longer of body. Three features made prominent by the breeders of these animals serve to make the Clydes rather distinctive. These are color, feather on the legs, and action. Bay or brown are the colors most desired. Formerly some of the animals were black, gray, or chestnut, but in 1827 the Highland Agricultural Society ruled that only bay or brown animals could compete for prizes in the shows. Naturally this caused breeders to choose individuals of these colors for mating and, as a result, most of the animals now seen are either bay or brown. The breeders desire, also, a white blaze on the face and white on one or more of the feet. The feather on the legs is very characteristic of the breed. This is the long silky hairs that grow on the back of the legs below the knees and hocks. In action the animals are unequaled by those of the other draft breeds, some horsemen claiming that the breeders lay too much stress on this quality.

Fig. 121. — Shire stallion.

Shire. — A native of England, the Shire (Fig. 121), is the result of crossing the native mares there and stallions brought from Normandy and Flanders. In general appearance Shire horses resemble Clydes, as they are usually bays or browns, have white markings on the face and legs, and feather on the legs. The stallions range in height from 16 to 17–2 hands and in weight from 1800 to 2400 pounds. The animals are low-set and the body is of good width, depth, and length, with heavily muscled shoulders

and thighs. The head of many of the animals is inclined to be a little plain with a slight lack in width of forehead and a coarseness about the muzzle. The nose is apt to be Roman which, if not too pronounced, is a feature desired by the breeders. In action the gait is a little sluggish, especially in the trot. Usually, however, the animals are good at the walk and the stride is long and straight.

FIG. 122. — Belgian mare.

Belgian. — The native home of this horse (Fig. 122), as the name implies, is Belgium. The animals are the result of the selection and mating of the native horses of Flanders, no outsiders having been used in the improvement. Belgian horses are the heaviest of the draft breeds, the stallions ranging in weight from 1800 to 2500 pounds and standing from 16 to 17 hands high. The animals have deep, thick bodies, and short legs that are free from feather. The neck is short and thick and carries a high crest, the latter being a pronounced feature. In action some judges criticize the animals as being slow and sluggish in the walk with too short a stride. They are, however, usually good at the trot, going true and straight. Chestnut, bay, and roan are the prevailing colors; sometimes black or gray is seen.

Suffolk. — The smallest of draft horses is the Suffolk (Fig. 123), a native of Suffolk County in eastern England. The animals range in height from 15–2 to 16–2 hands and in weight from 1700 to 1800 pounds. On account of their small size, they are better suited for agricultural purposes than for heavy draft work in the cities. In general appearance the animals show a full, round body set on short, clean legs. The neck is of good length and the crest is very well developed. The body is deep, the ribs well sprung, the rump full and round. The

FIG. 123. — Suffolk stallion.

legs are short and free from feather. In action the animals rank next to the Clydes. Chestnut is the characteristic color, light chestnut being preferred to dark.

166. The heavy-harness breeds. — Hackney, French Coach, German Coach, and Cleveland Bay are the heavy-harness breeds found in America. These, as stated previously, are the show horses of the parks.

Hackney. — The breed known as the Hackney (Fig. 124) originated in the counties of Norfolk and York, England. The foundation stock was Arabian, Barb, and Turkish stallions

crossed with native mares. In conformation the animals are rather short-legged and broad-bodied with a level back and well muscled loins. The head is neat and clean, the neck beautifully curved, the shoulders sloping, and neatly joined to the neck. They are among the most beautiful horses in the world. In height they vary from less than 14 hands to something over 16 hands. Three classes are recognized in England; those under 14 hands are classed as ponies, those from 14 to 15 hands

FIG. 124.—Irving Model, 1090. A Hackney pony stallion, for which $5000 was paid and $15,000 afterwards refused. Champion Hackney pony stallion of the National Horse Show, 1915.

as cobs, those 15 hands and over as carriage horses. In weight the largest Hackney seldom exceeds 1250 pounds. The action is high, quick, and elastic and the knees and hocks are usually well flexed. Individual animals, no matter how good their other qualities may be, if they lack in action, are discriminated against by breeders and purchasers. Chestnut, bay, black, gray, roan, and buckskin are the usual colors, chestnut predominating.

French Coach. — The name French Coach is applied to this breed in America, but in France, where the animals are native, the name Demi-Sang, meaning half-blood, is used. The breed dates back to the seventh century when by order of Louis XIV, Arabian, Barb, and Thoroughbred stallions were imported into France and crossed on the best saddle mares of Normandy. The first colts were termed half-bloods, which accounts for the name, Demi-Sang. Compared with the Hackneys the French Coach horses are a little less smooth and symmetrical, but are larger in body and bone and better muscled. In action the trot is not so high nor snappy, but the stride is more powerful and longer. The height ranges from 15 to 16 hands and the weight from 1200 to 1350 pounds. The prevailing colors are bay and brown, although black and chestnut are sometimes seen.

Fig. 125. — German Coach stallion.

German Coach. — The name German Coach (Fig. 125) is applied in America to any coach horse imported from Germany. In that country there are several breeds of coach horses, each with a separate registration society. Some of these breeds are Oldenburg, Hanoverian, Holstein, and East Friesland. As might be inferred, the coach horses coming to the United States from Germany are variable in size and conformation. They range in height from 15–2 to 17 hands and in weight from 1300 to 1500 pounds. Usually, the animals

are larger than those of the French Coach breed, the body being heavier and longer. In action they lack the height and stylishness of the Hackney, but the stride is somewhat longer. The prevailing colors are bay and brown, although black is not uncommon.

Cleveland Bay. — The breed known as the Cleveland Bay originated in the northeastern part of England and it is thought that the animals are the product of native mares crossed with Thoroughbreds. The breed is not especially popular in America and the horses are seldom seen at the shows. The animals range in height from 16 to 16–3 hands and in weight from 1200 to 1550 pounds. They are somewhat more upstanding and larger than Hackneys, have good quality, and strong action that lacks somewhat in style. The color is always some shade of bay, shading to black on the legs, tail, and mane.

167. The light-harness breed. — The only breed of light-harness horse in the United States is the Standard-bred, sometimes known as the American Trotter.

Standard-bred. — A product of America, the Standard-bred (Fig. 126) includes both trotters and pacers. The original stock was produced by native mares crossed with Thoroughbreds. The object in view was speed performance and, as might be expected, the type is not at all uniform. The animals range in height from 14 to 16 hands and in weight from 800 to 1100 pounds. A distinguishing characteristic is good action. Whether at trot or pace, the stride is long and rapid and the gait true and level. Bay and brown are the most common colors, but many other colors are found in the breed.

Standard-bred horses have been developed because of the interest of Americans in harness races. The history of the breed extends back to Colonial times when light horses were imported and bred in Massachusetts, Virginia, North and South Carolina. Several families of the breed have been developed, the most important of which are Hambletonian, Mambrino, Morgan, Clay, Blue Bull, and Pilot. Many

notable records have been made on the track by representatives of the breed.

168. The saddle-horse breeds. — The Thoroughbred, the American saddle horse, and the Arabian are the saddle-horse breeds represented in America.

Thoroughbred. — The English running horse, the Thoroughbred (Fig. 127), originated in the southern part of England,

Fig. 126. — Standard-bred horse.

and is the result of crossing the light-weight native mares of that region and the stallions of Arabian, Barb, and Turkish blood. Thoroughbreds range in height from 15 to 16 hands and in weight from 900 to 1200 pounds. In general appearance they are somewhat angular. They have fine, lean heads that possess much quality. The chest is often narrow, but it carries good depth. The back and loins are very well muscled and have great driving power. The action in desirable

FIG. 127. — A Thoroughbred horse.

specimens is very straight, free, and easy. In color the animals vary considerably, the most popular colors being bay and brown, although chestnut, black, sorrel, gray, and roan are often seen.

American saddlers.— As the name indicates, this saddle horse (Fig. 128) originated in America. It is the result of crossing native mares and Thoroughbreds. Horses used under the saddle have always been popular in the South and it is that section of the country to which credit must be given for the American saddle-horse breed. Gay has well described the animals as follows:

FIG. 128. — American saddle horse.

"Since their foundation, saddle horses have been selected to a model, as well as a performance, standard. They may be distinguished by the following characters: an upstand-

ing horse of most symmetrical and beautifully molded form, a well-proportioned, blood-like head, the features of which are most defined, an intelligent countenance, and an exceptionally long, shapely and supple neck, on which the head is set in a lofty, graceful manner. The two ends are the most characteristic parts of the saddle-bred horse, the long, level croup and unusually high-set and proudly-carried tail balancing the lofty carriage of head, in compliance with the Kentuckian's idea of 'Head up and tail a-risin'.' An extreme degree of quality, finish and style, with a rich bay, brown, chestnut, or black color, usually moderately and evenly marked with white, complete a beautiful picture horse. The way of going was formerly distinguished by the rack, but with the increasing favor shown the walk-trot-canter horse the rack has been omitted in many representatives of this breed. The trot is quite frequently marked by more action than is usually required of saddle horses, and is, in fact, well suited to harness performance. The highest class saddle-bred horse is a show horse in every sense of the word, whether under saddle or harness."

Fig. 129. — Arabian stallion, Cibolo, 134.

Arabian horses.— The native home of this horse (Fig. 129) is in the deserts of Arabia, where the animals have been bred for a long time by the migratory tribes that inhabit this region. So scattered are these tribes that little is known about the ancestry of the animals. True it is, however, that they have

followed true lines of breeding that have given Arabian horses of to-day beauty, style, stamina, and endurance that is not excelled by any other breed. Arabian horses have had a marked influence on the improvement of other breeds. They were used extensively for improving the Thoroughbred and the Hackney and, to somewhat less extent, the French Coach and the German Coach horses.

Regarding the height and weight of Arabians, H. K. Bush-Brown, Secretary of the Arabian Horse Club of America, states: "Horses of the Maneghi-Hadruji family of Arabs are the largest, sometimes attaining 16 hands, but usually ranging from 15 to 15–2 hands. Other pure-bred Arabs are from 14 to 15 hands. They weigh from 850 to 1000 pounds and as they are very compactly built they are heavy for their inches and seem larger than they are."

The Arabian is a symmetrical, stylish horse. The head is broad and high, the ears small and well set, the nostrils large, the neck of good length and well shaped. The body is shorter than that of the Thoroughbred; the ribs are well covered with flesh and spring out from the spine with a graceful, symmetrical curve. The animals have one less vertebra than any of the other breeds, which is an advantage in carrying weight in the saddle.

169. Ponies. — The small size of the animals of the pony breeds is no doubt due in a large measure to adverse climatic conditions and scanty food supply. Ponies as bred to-day are kept to their diminutive size by careful selection and breeding. The three chief breeds are the Shetland, the Welsh, and the Hackney. In America certain groups of ponies not recognized as breeds are the familiar bronchos, mustangs, and Indian ponies of the western plains.

Shetland ponies. — The Shetland is a native of the Shetland Islands, a group of islands north of Scotland where the winters are long and severe and the feed scanty. In size Shetlands range from 30 to 46 inches and in weight from about 325 to

385 pounds. Small size, of course, is desired and, for this reason, the registry associations discriminate against animals over a certain height. The association in Scotland will not register an individual that is over 42 inches high; in America those up to 46 inches may be registered. Shetland ponies have the general appearance of a very small, chunky draft horse. A wide variation in color is found, bay, brown, black, chestnut, and gray being rather common colors. Many have white markings. Shetlands are very desirable for children, being docile and easily controlled.

Welsh ponies. — This breed of ponies is a native of Wales. The animals are somewhat larger than the Shetlands, ranging from 11 to 13 hands. In conformation they are of the light-horse type. In temperament they are more active than the Shetlands and less desirable for young children. The ponies are extensively used for polo purposes.

Hackney ponies. — Any small Hackney horse is known as a Hackney pony, size being the only distinguishing difference between the horse and the pony. A Hackney pony is shown in Fig. 124.

Bronchos and Indian ponies. — The American ponies of the western plains are thought to be descendants of horses that were lost by the early explorers. These ponies have a remarkable capacity for hard work under the saddle. Formerly they were much used as cow ponies, but in recent years larger horses have been preferred for this purpose. Many of the pony mares have been crossed with larger stallions and the offspring, which are somewhat larger than the ponies, have been found useful as tough riding and driving horses.

170. Market classes of horses and mules. — At Chicago, St. Louis, Kansas City, Omaha, Buffalo, Boston, New York, and some other cities, there are large horse and mule markets where the animals offered for sale are grouped in certain classes based on such qualities as soundness, conformation, quality, condition, action, age, color, education, and general appear-

ance. An exhaustive study of the market classes of horses and mules was made a few years ago by R. C. Obrecht, of the University of Illinois, and published as Bulletin 122 of the Agricultural Experiment Station of Illinois. Table XI, which follows, is from this bulletin, and will be found valuable for reference.

TABLE XI

MARKET CLASSES OF HORSES AND MULES WITH LIMITS IN HEIGHT AND WEIGHT

Classes	Sub-classes	Height hands	Weight pounds
Draft horses	Light draft	15–3 to 16–2	1600 to 1750
	Heavy draft	16 to 17–2	1750 to 2200
	Loggers	16–1 to 17–2	1700 to 2200
Chunks	Eastern and export chunks	15 to 16	1300 to 1550
	Farm chunks	15 to 15–3	1200 to 1400
	Southern chunks	15 to 15–3	800 to 1250
Wagon horses	Expressers	15–3 to 16–2	1350 to 1500
	Delivery wagon	15 to 16	1100 to 1400
	Artillery horses	15–1 to 16	1050 to 1200
	Fire horses	15 to 17–2	1200 to 1700
Carriage horses	Coach	15–1 to 16–1	1100 to 1250
	Cobs	14–1 to 15–1	900 to 1150
	Park horses	15 to 15–3	1000 to 1150
	Cab	15–2 to 16–1	1050 to 1200
Road horses	Runabout	14–3 to 15–2	900 to 1050
	Roadster	15 to 16	900 to 1150
Saddle horses	Five-gaited Saddler	15 to 16	900 to 1200
	Three-gaited Saddler (Light, Heavy)	14–3 to 16	900 to 1200
	Hunters (Light, Middle, Heavy)	15–2 to 16–1	1000 to 1250
	Cavalry horses	15 to 15–3	950 to 1100
	Polo ponies	14 to 14–2	850 to 1000
Mining mules		12 to 16	600 to 1350
Cotton mules		13–2 to 15–2	750 to 1100
Sugar mules		16 to 17	1150 to 1300
Farm mules		15–2 to 16	900 to 1250
Draft mules		16 to 17–2	1200 to 1600

171. Breaking and training colts.[1] — The future value and usefulness of a colt depends largely on whether or not he is broken and trained so that he is safe to handle in the stable and on the road and will obey orders of the rider or driver promptly. The work of breaking and training should be done when the animals are young, for old horses are much more difficult to train than colts. The usual plan is to teach the colt to stand tied and to lead before he is weaned and to break him to harness and saddle between the ages of two and three years.

Teaching the colt to stand tied. — The first step is to teach the colt to stand tied. This is accomplished by the use of halter and ropes. First, place a halter on the animal, double a four-foot rope, put the loop under the tail as a crupper, make three twists in the rope, bring the two ends forward, and tie them together in front of the chest. Next, tie a rope loosely about the body back of the withers and knot it on both sides to the crupper rope. With these ropes in position pass a twelve-foot rope through the halter ring and tie one end to the crupper rope at the breast of the animal and hitch the other end to a strong post, leaving about three feet of slack.

Gentling the colt. — While tied the colt should be petted and rubbed on the sides, hindquarters, and legs. This operation is termed gentling. Hold the head-stall in one hand and with the other pet and rub the head and neck. Then, gentle the back, the sides, and lastly, the legs. In gentling the hind parts make use of a stick about four feet long on one side of which is a burlap bag wrapped and tied. First, let the colt smell the stick, then rub the padded part over the legs and on the body. If the colt kicks do not beat him, allow him to examine the stick again, then rub him as before. The gentling should be continued until the colt can be approached from either side and rubbed all over his body.

The second lesson should be the same as the first, teaching him to stand tied and to be rubbed and petted.

[1] Based on Farmers' Bulletin 667.

Teaching the colt to lead. — At the third lesson he should be broken to the lead. To do this, loosen the rope from the post, step away from the colt, tell him to come and follow the command with a pull on the rope. As soon as he steps forward pet him, then step away and repeat the command. Soon he will follow without the pull on the rope. About half an hour is long enough for this lesson.

The next lesson should be started with the crupper rope in position, but it should be removed after a brief workout and the halter used alone. Lessons without the crupper rope should be continued until the colt has learned to lead well.

Handling the feet of the colt. — While breaking a colt to lead, it is well to accustom him to having his feet handled and also to trim the hoofs. Careful trimming of the feet of colts often avoids such trouble as knock-knees, bow-legs, pigeon-toes, cow-hocks, interfering, and paddling. Begin the work of handling the feet with the near front foot. Tie a rope around the pastern, grasp the rope close to the foot, push against the shoulder of the colt, and at the same time quickly lift the foot, rub it gently, and let it down. Repeat this operation several times after which trim and level the hoof. To raise a hind foot, put a rope on the pastern, draw the foot forward, and smooth it with the hand. Repeat this several times and follow by bringing the foot to the shoeing position and trimming the hoof.

Teaching the colt the commands used in driving. — After a colt has been broken to lead he should be broken to drive in the harness. This means to go forward, to stop, to rein to right or left, and to back. A bitting harness may be used to accustom the colt to bit and harness. This consists of an open bridle and snaffle bit, check and side reins, surcingle, and crupper. For the first lesson leave side and check reins loose and turn the colt into a small paddock for an hour. On the next day tighten the reins a little and turn him loose again for an hour. On the third day put on the driving lines, take

a position behind him with the lines in hand, and have an assistant lead him. As soon as he becomes accustomed to the driver, do without the assistant. Drive the colt for half an hour in a paddock or lane where there are no other horses. This lesson is to teach him to go forward, nothing else. Use the whip, click to him, or say " get up " to let him know what is wanted. It is necessary to drive in a circle both to the right and the left as this makes the colt familiar with objects on both sides of him. Often an animal will be accustomed to objects on one side, but will be frightened when they are seen for the first time on the other.

In the next lesson the colt should be driven for a while, then taught to stop at the command " whoa." To stop a colt say " whoa " loud enough to be heard plainly and follow with a pull on the reins. In making this pull, hold one of the reins tight and pull with the other, then relax. If the colt does not stop, repeat the command and the pull. As soon as he has learned to stop in this way, teach him to stop by giving the command only, not the pull.

During the first part of the next lesson, the " get up " and " whoa " commands should be reviewed, after which he should be taught to back. To do this, drive him a few steps forward, stop him, give the command " back " followed by a pull on the lines. If he backs pet him and repeat the command. Do not keep up a steady pull on the lines, as this may cause him to take the bit and forge ahead. Make the lesson short, give another the next day, and continue the lessons until he has been well trained to drive in bitting harness.

The work harness is next substituted for the bitting harness. Fasten the traces and breeching together loosely at first and tighten them gradually as the training progresses.

Driving in double harness. — For the first lesson in double harness, hitch the colt with a gentle horse and drive them for half an hour without a wagon. At the next lesson the first step is to make him familiar with the wagon. Lead him up

to it, let him smell it, rattle it, and lead him around it. Then, lead the team horse to his place at the tongue, bring the colt up, attach the lines, the neck yoke, and the traces, and hitch the two animals together. Next, have an assistant take the colt's lead rope. Drive a few steps and stop, using the break to hold the wagon away from the team. Have the assistant pet the colt to quiet him and when he is quiet start again, this time going a little farther than the first time. As soon as he gets over being frightened, drive in a circle a few times. Stop occasionally and quiet him and when he goes well have the assistant get into the wagon. Take only a short drive and when the colt shows signs of fear, stop and let him examine whatever may have frightened him. Keep up the lessons, taking a longer ride each day until the colt is broken.

Driving in single harness. — Put the colt in single harness, using an open bridle, lead him to the cart and allow him to examine it. A two-wheel breaking cart with long shafts is best for this purpose. Have an assistant draw the cart around the colt a few times and after he shows no signs of fear, raise the shafts and draw the cart up to place. After he has been hitched, get into the seat and have the assistant lead the animal for a while. Later drive without the aid of an assistant. Start the colt quietly, drive a few steps, stop and pet him. Keep this up for several lessons until the animal can be driven quietly.

Breaking the colt to ride. — When a colt is to be broken to ride, it is well first to break him to drive both single and double, then break him to ride. Put on the saddle and lead him around. Tie him up for a while and, keeping the saddle on, turn him into a paddock. Next, accustom him to being mounted by getting on and off several times. After he is accustomed to the mounting, get on his back and have an assistant lead him. As soon as possible, ride him without the aid of an assistant. If the colt gets unruly, pull his head to one side, and do not let him get it down. Keep up the lessons until he will go forward, back, stop, and so on, at the will of the rider.

172. Feeds for horses. — Oats is the grain used most extensively in the United States for horses, but it is becoming so expensive in some parts of the country that there is a constant demand for other feeds to take its place. Corn is most commonly substituted and it has been found to be a safe and satisfactory feed when used in the correct proportion. At the New Hampshire Station, a mixture of one part of bran and one part of corn was found to be a good substitute for oats. Barley is much used on the Pacific Coast. Kafir corn is used in the semi-arid regions of the country. Factory by-products make good feed and are extensively used. Bran, shorts, gluten feed, linseed meal, and cottonseed meal are often included in the rations for horses.

Timothy and prairie hay are the most used hays for horses, although in many sections where these are not produced others are substituted. At the North Dakota Station, brome-grass hay was found to give as good results as timothy. At the Utah Station, alfalfa when judiciously fed was found to be satisfactory. When feeding alfalfa hay, less grain is required in the ration than if timothy hay is fed. At the Illinois Station, from 20 to 22 per cent less hay was required to maintain the weight of horses fed with alfalfa than those fed with timothy. At the same station, a slight difference was observed in favor of clover hay over timothy hay.

In Table XII are given examples of rations actually fed to horses in the different parts of the country. It will be noticed that there is a predominance of oats and corn in the rations.

173. Time to water horses.[1] — The proper time to water horses is a matter concerning which opinions differ. Many feeders believe that they should be watered before feeding, while others are equally certain that feeding should precede watering. Some extended experiments have been recently made in Europe which have led to definite conclusions, and seem to have reached the truth in the matter.

[1] C. F. Langworthy in Farmers' Bulletin 170.

TABLE XII

Rations for Horses

Kinds of Horses	Weight of Horses	Rations
	Lb.	Lb.
ARMY HORSES		
United States: Cavalry . . .	1,050	Oats, 12; Hay, 14
Artillery . .	1,125	Oats, 12; Hay, 14
Mules . . .	1,025	Oats, 9; Hay, 14
HORSES WITH LIGHT WORK		
Driving horse, Wyoming Station	1,200	Alfalfa, 21.25; Straw, 3.2
Carriage horse .	1,050	Oats, 10; Hay, 12
Fire company horses:		
Boston, Mass .	1,400	Ground grain, 9.38; Hay, 18
Chicago, Ill. .	1,350	Oats, 4; Hay, 15
HORSES WITH MODERATE WORK		
Express horses:		
Richmond, Va., summer . .	1,400	Corn, 4.67; Oats, 5.33; Bran, 0.83; Corn meal, 4.16; Hay, 15
Jersey City, N. J. . . .	1,325	Corn, 2; Oats, 19; Bran, 1.5; Hay, 9.5
Boston, Mass.	1,325	Corn, 12; Oats, 5.25; Hay, 20
Cab horses:		
Washington, D. C. . . .	1,200	Oats, 10; Corn, 5; Hay, 23
San Francisco, Cal. . . .	1,350	Oats, 8; Hay, 16

Kinds of Horses	Weight of Horses	Rations
	Lb.	Lb.
Farm horses:		
California Station . . .	1,000	Alfalfa hay, 12; Wheat hay, 11; Crushed barley, 7
California Station . . .	1,000	Alfalfa hay, 10; Barley hay, 12; Cracked corn, 7
Wyoming Station . . .	1,000	Alfalfa, 13.75; Straw, 2.25
New Hampshire Station . .	1,235	Bran, 2; Corn, 6; Gluten meal, 6; Hay, 10
New Jersey Station . .	1,000	Hay, 6; Bran $2\frac{1}{4}$; Corn, $4\frac{3}{4}$; Dried brewers' grain, $8\frac{1}{4}$
Massachusetts Station . .	1,100	Hay, 18; Wheat bran, 2; Provender, 6 = crushed corn, 2.73; oats, 3.27
Utah Station .	1,370	Alfalfa hay, 25; Bran and shorts (1 : 1), 10
Utah Station .	1,325	Timothy hay, 22.8; Bran and shorts (1 : 1), 10
Farm mules, Virginia Station	1,310	Hay, 15.2; Corn, 10.5; Corn silage, 10.5
HORSES WITH SEVERE WORK		
Truck and draft horses:		
Chicago, Ill., daily ration	1,500	Oats, 7.5; Hay, 20
South Omaha, Nebr. . . .	1,500	Oats, 15; Hay, 12

So far as was observed, the time of drinking had no effect on the digestibility of a ration of grain and hay. When hay only was fed there seemed to be a slight advantage in watering before feeding. The general conclusion was drawn that horses may be watered before, during, or after meals without interfering with the digestion and absorption of food. All these methods of watering are equally good for the horse, and each of them may be employed according to circumstances. It is obvious that certain circumstances may make it necessary to adopt one or the other method. For instance, after severe loss of water, such as occurs in consequence of long-continued, severe exertion, the animal should always be allowed to drink before he is fed, as otherwise he will not feed well.

In this connection it is worth noting that many American farmers believe that watering before feeding is best. Although all methods of watering seemed in these tests to be equally good for the horse, it is not desirable to change unnecessarily from one method to another. Animals, or at least some of them, appear to be not altogether indifferent to such a change. In the experiments referred to above, it was found that whenever a change was made from the plan of watering after feeding to that of watering before, the appetite fell off for some days; not that the horses did not consume the whole of the food given to them, but for some days together they did not eat with the same avidity as before, and took a longer time to consume their rations completely. A similar effect was not observed when the change was from watering before to watering after feeding, or from watering after to watering during meals, or when the change was in the opposite direction to the last. It seems best, therefore, to avoid sudden and unnecessary changes in the method of watering.

174. Soundness in horses. — A horse with a disease or a vice that interferes with his usefulness or makes him incapable of reasonable work is termed unsound. The term serviceably sound is often used to indicate horses that have no defects

that make them unfit for the use for which they are sold. In the Chicago horse market, this term has been abandoned, as its use created many opportunities for controversy. Some unsoundnesses that unfit a horse for hard service are broken wind, unsound eyes, side bones, ring bones, large splints, buck knees, curbs, spavins, and large thoroughpins. In Table XIII is given the location of the common unsoundnesses and faults of horses.

TABLE XIII

LOCATION OF THE COMMON UNSOUNDNESSES AND FAULTS OF HORSES

NAME	LOCATION
Unsound eyes	Head
Wind broken	Body
Poll evil	Head
Fistula	Withers
Shoulder sweeny	Shoulder
Collar boil	Shoulder
Shoe boil	Elbow
Knee sprung	Knee
Splints	Cannons
Bowed tendons	Cannons
Wind gall	Fetlock joint
Grease	Fetlock joint
Ring bones	Pastern
Side bone	Cornets
Quittor	Cornets
Founder	Feet
Thrush	Feet
Quarter crack	Feet
Toe crack	Feet
Broken ilium	Hips
Knocked-down hip	Hips
Hip sweeny	Hips
Dislocated patella	Stifle
Bone spavin	Hock
Bog spavin	Hock
Thoroughpin	Hock
Curb	Hock
Capped hock	Hock

175. Determining age of horses. — The following is a description of the method employed in determining age in

horses, as published by the United States Department of Agriculture.

"Until a horse is over 10 years old the teeth furnish an indication of age which is fairly accurate. In estimating the age of a horse, only the three pairs of front teeth or nippers on each jaw are considered. Horses, like human beings, have two sets of teeth; the first set, known as milk teeth, being replaced by permanent teeth. New teeth have deep cups, or indentations, at their centers. As the teeth wear down these cups disappear.

"A colt does not usually get its first pair of nippers until it is a few days old, but has all three pairs by the time it is 6 to 10 months old. Until a colt is 3 years old, however, its general appearance is relied upon largely to indicate its age. Following is a description of the yearly changes which ordinarily occur in the teeth of a horse.

"*One year.* — The center pair of milk incisors, known as the pinchers, and the pair next to them, known as the intermediates, are well through the gums and in contact, but the corner pairs do not yet meet on a level.

"*Two years.* — The pinchers and the intermediates indicate that they are being crowded by the permanent teeth, as they are pushed free from their gums at the base. By the time the colt is 2½ years old the middle pinchers should be through. The permanent teeth are much larger than the temporary ones.

"*Three years.* — The middle pinchers are large enough for use. Their deep cups show plainly. The milk intermediates are about to be shed.

"*Four years.* — The permanent intermediates appear at 3½ years and are ready for use at 4. The corner teeth give evidence that the permanent corners are coming. The cups in the pinchers are about one-third gone. (The tusks, or canine teeth, of male colts may appear about this time.)

"*Five years.* — The temporary corner teeth are shed at 4½ and the permanent ones are ready to use. The horse has now

what is known as a full mouth, all permanent incisors being ready to use. The cups of the first pair are about two-thirds gone.

" *Six years.* — The cups in the center pair have nearly disappeared. In the second pair they are about two-thirds gone.

" *Seven years.* — The cups from the second pair are now gone. There is a notch in the upper corner tooth where it overlaps the lower one.

" *Eight years.* — The cups having all worn out of the lower nippers, we now look at the upper jaw. Although cups remain in the center pair, they are not deep.

" *Nine years.* — The cups in the center pair of nippers on the upper jaw have disappeared. They are still present in the other two pairs, being fairly deep in the corner ones.

" *Ten years.* — The cups are worn out of the second pair on the upper jaw, although they are still present in the corner pair.

" *Older horses.* — At 11 years all of the cups are usually worn out of the incisors and it becomes necessary to use some other indication. Estimation of age may now be based upon the angle at which the teeth meet, their change in size and shape. As the horse gets older, the teeth meet more and more at an acute angle; that is, the jaws become more oblique. As the teeth wear down, the shape of the worn ends changes from oval to more nearly round and, finally, in an aged horse, to a nearly triangular form. Sometimes cups are cut or burned in the teeth of old horses to make their mouths resemble those of younger animals. This practice, known as 'Bishoping,' may be detected if the shape of the tooth and the absence of the ring of enamel which surrounds the natural cup are noted. After a horse is 12 years old its condition is more important than its age in determining values."

QUESTIONS

1. How is the height of horses measured?
2. Describe a typical draft horse.
3. Why is good knee and hock action so much desired in heavy-harness horses?

4. What quality is of especial importance in roadster horses?
5. What gaits must a five-gaited saddler show?
6. Describe the canter, the rack, the running walk, the fox-trot, and the slow pace.
7. Compare the Percheron and the Clydesdale as to conformation.
8. Why do breeders of Hackney horses discriminate against horses that lack high action?
9. Which breeds of horses originated in America?
10. In determining the market class to which a horse belongs what qualities are considered?
11. Which grain is fed most extensively to horses and why are other feeds sought to take its place?
12. Discuss the question of the proper time to water horses.
13. What is meant by an unsound horse?
14. Name some unsoundnesses that unfit a horse for hard service.
15. What three important qualities should a saddle horse possess?

EXERCISES

1. **Scoring draft horses.** — Study the score-card carefully. The one shown here is used by Purdue University, Lafayette, Indiana, and is an exceptionally good one. Notice the relative weights allowed for general appearance, head and neck, forequarters, body, hindquarters, and action. Read the list of qualifications of each point and decide why these qualifications are desired in a draft horse.

SCORE-CARD — DRAFT HORSES FOR MARKET

SCALE OF POINTS	STANDARD	POINTS DEFICIENT	
		Student's Score	Corrected
General appearance — 19 per cent:			
1. Height, estimated .... hands; actual .... hands		.....	.....
2. Weight, over 1600 lb., estimated .... lb., actual .... lb., according to age . .	6	.....	.....
3. Form, broad, massive, well proportioned, blocky, symmetrical	4	.....	.....
4. Quality, refined; bone clean, hard, large, strong; tendons clean, defined; skin and hair fine; feather, if present, silky . . .	6	.....	.....
5. Temperament, energetic; disposition good .	3	.....	.....

SCORE-CARD — DRAFT HORSES FOR MARKET (*Continued*)

Scale of Points	Standard	Points Deficient: Student's Score	Points Deficient: Corrected
Head and neck — 9 per cent:			
6. Head, lean, proportionate size; profile straight	1	.....	.....
7. Ears, medium size, well carried, alert . . .	1	.....	.....
8. Forehead, broad, full	1	.....	.....
9. Eyes, full, bright, clear, same color . . .	2	.....	.....
10. Lower jaw, angles wide, clean	1	.....	.....
11. Muzzle, neat; nostrils large, open, free from discharge; lips thin, even, firm	1	.....	.....
12. Neck, well muscled, arched; throatlatch clean; windpipe large	2	.....	.....
Forequarters — 24 per cent:			
13. Shoulders, moderately sloping, smooth, snug, extending into back	3	.....	.....
14. Arm, short, strongly muscled, thrown back, well set	1	.....	.....
15. Forearm, strongly muscled, wide, clean . .	2	.....	.....
16. Knees, deep, straight, wide, strongly supported	2	.....	.....
17. Cannons, short, wide, clean; tendons defined, set back	2	.....	.....
18. Fetlocks, wide, straight, strong, clean . . .	1	.....	.....
19. Pasterns, moderate length, sloping, strong, clean	2	.....	.....
20. Feet, large, even size, sound; horn dense, waxy; sole concave; bars strong; frog large, elastic; heel wide and one-fourth to one-half the lineal length of toe	8	.....	.....
21. Legs, viewed in front, a perpendicular line from the point of the shoulder should fall upon the center of the knee, cannon, pastern, and foot. From the side, a perpendicular line dropping from the center of the elbow joint should fall upon the center of the knee and pastern joints and back of the hoof .	3	.....	.....
Body — 9 per cent:			
22. Chest, deep, wide, large girth	2	.....	.....
23. Ribs, long, well sprung, close; coupling strong	2	.....	.....
24. Back, straight, broad, strongly muscled . .	2	.....	.....
25. Loins, wide, short, thickly muscled . . .	2	.....	.....
26. Underline, low; flanks full	1	.....	.....

Score-card — Draft Horses for Market (*Continued*)

Scale of Points	Standard	Points Deficient	
		Student's Score	Corrected
Hindquarters — 30 per cent:			
27. Hips, broad, smooth, level, well muscled	2	.....	.....
28. Croup, not markedly drooping, wide, heavily muscled	2	.....	.....
29. Tail, stylishly set and carried	1	.....	.....
30. Quarters, deep, broad, heavily muscled, thighs strong	3	.....	.....
31. Gaskins, long, wide, heavily muscled	2	.....	.....
32. Hocks, large, clean, strong, wide, well set	6	.....	.....
33. Cannons, short, wide, clean; tendons defined	2	.....	.....
34. Fetlocks, wide, straight, strong, clean	1	.....	.....
35. Pasterns, moderately sloping, strong, clean	2	.....	.....
36. Feet, large, even size, sound; horn dense, waxy; sole concave; bars strong; frog large, elastic; heel wide, and one-fourth to one-half the lineal length of the toe	6	.....	.....
37. Legs, viewed from behind, a perpendicular line from the point of the buttock should fall upon the center of the hock, cannon, pastern, and foot. From side, a perpendicular line from the hip joint should fall upon the center of the foot and divide the gaskin in the middle, and a perpendicular line from the point of the buttock should run parallel with the line of the cannon	3	.....	.....
Action — 9 per cent:			
38. Walk, fast, elastic, regular, straight	6	.....	.....
39. Trot, free, springy, balanced, straight	3	.....	.....
Total	100	.....	.....

With a draft horse before you mark in the space for student's score the weight you think should be given to each point. Seldom will two persons score an animal alike in all points or even in total score. Two good judges may differ in the relative worth of the different points, but when comparing one animal with another they are likely to agree as to which one is the better.

If an animal is nearly perfect in any point do not make a deduction,

or cut, but write the full amount in the space provided. If a point is not up to standard, make a cut; write what you think the animal is worth in this particular point. It is not advisable to make a cut of less than .25 and seldom will an animal be so deficient that a cut of half the rating of the point will be made. There can be no set rule for making cuts, because, as stated previously, two judges will seldom agree as to the relative value of a point; consequently, they would not agree as to the amount the point should be cut. After all the points have been rated add the numbers representing the relative weights; the sum is the score of the animal. A horse that scores 80 is a good one; do not be surprised if you find animals scoring less than this amount.

2. **Comparative judging of draft horses.** — After having had practice in scoring draft horses, you should learn to do comparative judging — that is, when two or more horses are placed together to select the best individual, the next best, and so on, without the aid of the score-card. To do this proceed as follows: Observe the general method of viewing the animals as given when scoring them. Study the horses by making comparisons part by part. For example study the general appearance of all the animals and determine in which points one animal is better than another and how a second is better than a third. Then, in your notebook, designate in which order they should be placed in general appearance, stating your reasons for placing them thus. Next, follow the same plan for forequarters and so on through the list on the score-card. With your notes before you, taking into consideration the relative weights of the different points, decide which horse is the best, which one is next best, and so on until you have them placed in order of merit.

After you have had considerable practice in judging it will not be necessary to make so many notes. You will be able to carry in mind the relative qualities of the different animals and decide which ones excel in the most points.

3. **Judging light horses.** — After having had practice in judging heavy horses you should be able to place light horses in order of merit by comparing the different qualities. The descriptions of the light horses of the different types have been given on previous pages. Study these descriptions and the score-card for light horses given herewith and place the horses accordingly.

Score-card for Light Horses[1]

Scale of Points for Gelding	Perfect Score	Student's Score	Corrected Score
1. Age	.....	.....	.....
General appearance — 12 points:			
2. Weight	.....	.....	.....
3. Height	.....	.....	.....
4. Form, symmetrical, smooth, stylish	4	.....	.....
5. Quality, bone clean, fine, yet indicating sufficient substance: tendons defined, hair and skin fine	4	.....	.....
6. Temperament, active, good disposition	4	.....	.....
Head and neck — 6 points:			
7. Head, lean, straight	1	.....	.....
8. Muzzle, fine, nostrils large, lips thin, even	1	.....	.....
9. Eyes, full, bright, clear, large	1	.....	.....
10. Forehead, broad, full	1	.....	.....
11. Ears, medium size, pointed, well carried, and not far apart	1	.....	.....
12. Neck, muscled; crest high; throat latch fine; windpipe large	1	.....	.....
Forequarters — 23 points:			
13. Shoulders, long, smooth, well muscled; oblique, extending into back and muscled at withers	2	.....	.....
14. Arm, short, thrown forward	1	.....	.....
15. Forearm, muscled, long, wide	2	.....	.....
16. Knees, clean, wide, straight, deep, strongly supported	2	.....	.....
17. Cannons, short, wide; sinews large, set back	2	.....	.....
18. Fetlocks, wide, straight	1	.....	.....
19. Pasterns, strong, angle with ground 45°	3	.....	.....
20. Feet, medium, even size, straight; horn dense; frog large, elastic; bars strong; sole concave; heel wide, high	6	.....	.....
21. Legs, viewed in front, a perpendicular line from the point of the shoulders should fall upon the center of the knee, cannon, pastern, and foot. From the side, a perpendicular line dropping from the center of the elbow joint should fall upon the center of the knee and pastern joints and back of hoof	4	.....	.....

[1] From U. S. Dept. Agr. Bul. 487.

SCORE-CARD FOR LIGHT HORSES (*Continued*)

SCALE OF POINTS FOR GELDING	PERFECT SCORE	STUDENT'S SCORE	CORRECTED SCORE
Body — 9 points:			
22. Chest, deep, low, large girth	2	.....	.....
23. Ribs, long, sprung, close	2	.....	.....
24. Back, straight, short, broad, muscled	2	.....	.....
25. Loin, wide, short, thick	2	.....	.....
26. Underline, long; flank let down	1	.....	.....
Hindquarters — 30 points:			
27. Hips, smooth, wide, level	1	.....	.....
28. Croup, long, wide, muscular	2	.....	.....
29. Tail attached high, well carried	1	.....	.....
30. Thighs, long, muscular, spread, open angled	2	.....	.....
31. Quarters, heavily muscled, deep	2	.....	.....
32. Gaskins or lower thighs, long, wide, muscular	2	.....	.....
33. Hocks, clearly defined; wide, straight	7	.....	.....
34. Cannons, short, wide; sinews large, set back	2	.....	.....
35. Fetlocks, wide, straight	1	.....	.....
36. Pasterns, strong, sloping	2	.....	.....
37. Feet, medium, even size; straight; horn dense; frog large, elastic; bars strong; sole concave; heel wide, high	4	.....	.....
38. Legs, viewed from behind, a perpendicular line from the point of the buttock should fall upon the center of the hock, cannon, pastern, and foot. From the side, a perpendicular line from the hip joint should fall upon the center of the foot and divide the gaskin in the middle; and a perpendicular line from the point of the buttock should run parallel with the line of the cannon	4	.....	.....
Action — 20 points:			
39. Walk, elastic, quick, balanced	5	.....	.....
40. Trot, rapid, straight, regular, high	15	.....	.....
Total	100	.....	.....

NOTE TO TEACHERS. — In this volume space is not available for considering the subject of stock-judging very extensively; in fact, a volume of several hundred pages is necessary to cover the subject thoroughly; such volumes are listed in the references. If much time can be devoted to stock-judging in your school, it will be well to adopt a

specific book on the subject. The bulletins and circulars listed as references are used in many schools as guides to the study of stock-judging.

Frequent practice in scoring and judging of live-stock is necessary if the pupils are to become at all proficient in the work.

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CHAPTER XVI

BEEF AND DUAL-PURPOSE CATTLE

Types of cattle.
Conformation of beef animals.
Conformation of dual-purpose animals.
Breeds of beef cattle.
Shorthorn, Polled Durham, Hereford, Polled Hereford, Aberdeen-Angus, Galloway.
Breeds of dual-purpose cattle.
Dual-purpose Shorthorns, Red Poll, Devon.
Market classes and grades of beef cattle.
Feeding of beef cattle.
Rations for beef cattle.

THE number of beef cattle in the United States has greatly decreased in recent years. As a result, high prices are paid for good beef animals; this has caused a greater interest in the production of beef and many farmers are now going into this line of work. Until recently, the Central States and the western plains produced most of the beef cattle of the country, but now many herds are to be found in the East and the South.

176. Types of cattle. — Cattle kept primarily for the production of beef are known as beef cattle; those kept primarily for the production of milk, as dairy cattle; and those kept for the production of both beef and milk, as dual-purpose cattle. Beef cattle have been carefully developed with the idea of producing a maximum quantity of best quality beef. The cows give milk enough for their calves, but little more. Beef animals are not satisfactory for milk production. Dairy cattle have been developed for the secretion of large quantities of milk and are undesirable for beef. Dual-purpose cattle have

been developed to produce females that will yield a fair quantity of milk and bear offspring that are desirable for beef. This chapter deals with beef and dual-purpose animals, discussion of dairy cattle being reserved for a later chapter. The external parts of the beef and dual-purpose animals are indicated in Figs. 130 and 131.

177. Conformation of beef animals. — Cattle belonging to the beef class should possess a certain conformation of body.

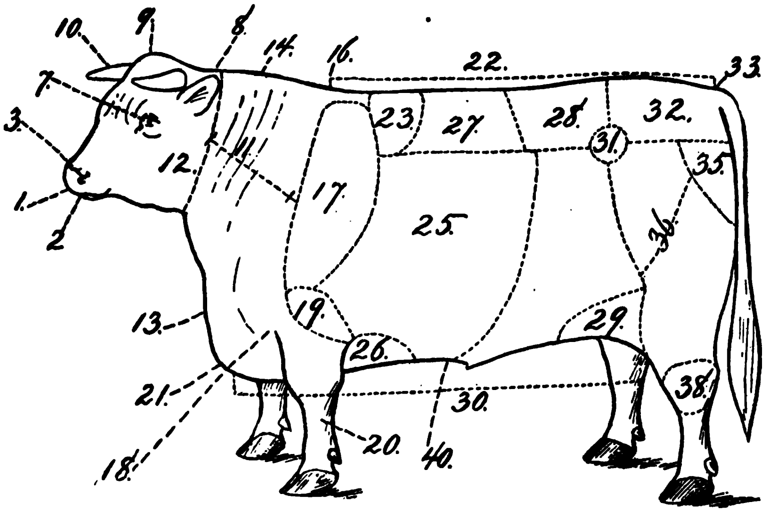

FIG. 130. — Points of beef cattle, side view. 1, muzzle; 2, mouth; 3, nostril; 7, eye; 8, ear; 9, poll; 10, horn; 11, neck; 12, throat; 13, dewlap; 14, top of neck or crest; 16, top of shoulder; 17, shoulder; 18, point of shoulder; 19, arm; 20, shank; 21, brisket; 22, topline; 23, crops; 25, ribs, or barrel; 26, fore flank; 27, back, or chine; 28, loin; 29, hind flank; 30, underline, or bottom line; 31, hip, point of hip, hook, or hook bone; 32, rump; 33, tailhead; 35, buttocks; 36, thigh; 38, hock; 40, navel.

They are short in the neck and legs, broad and deep in body, well filled along the back, with a good spring of rib, and straight top and bottom lines. When viewed from the side, the body approaches a parallelogram in shape, as indicated by the lines in Fig. 132. The butcher desires an ani-

mal with the greatest proportion of high-priced cuts and the smallest proportion of low-priced cuts. The different cuts of beef with the relative wholesale prices of normal times are

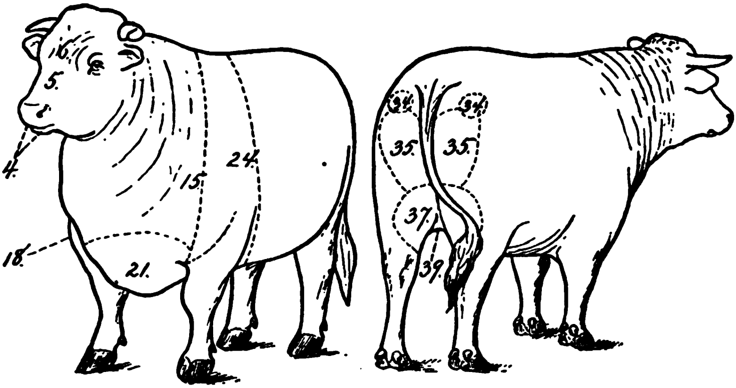

FIG. 131.—Points of beef cattle, front and rear views. 4, lips; 5, face; 6, forehead; 15, neck vein, or shoulder; 18, point of shoulder; 21, brisket; 24, girth; 34, pin bones; 35, buttocks; 37, twist; 39, purse.

shown in Fig. 133. The best animal from the butcher's standpoint is one with the greatest development of the upper half of the body and the smallest amount of head, neck, legs, and waste. Such an animal is most nearly approached in the parallelogram form of the beef animal. The feeder of beef cattle looks for an animal that will have this form when the feeding period is finished, and he desires an individual of good feeding ca-

FIG. 132.—A prime steer. The lines show the parallelogram shape desired in beef cattle.

pacity, breadth and fullness in the chest and heart girth, and one in thrifty condition.

178. Conformation of dual-purpose animals. — Dual-purpose animals are less uniform in conformation than beef or dairy cattle. Some incline more toward the beef type and others toward the dairy type. Compared with beef animals, they show a longer neck, less tendency toward putting on fat, and the females are better developed in the udder, a dairy characteristic.

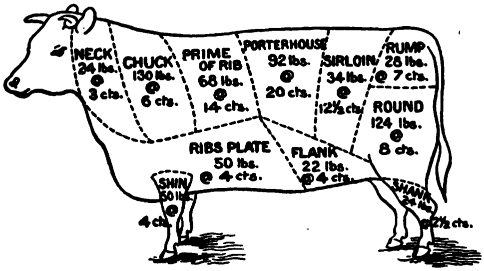

Fig. 133. — Cuts of beef.

179. Breeds of beef cattle. — The beef breeds in the United States are Shorthorn, Polled Durham, Hereford, Polled Hereford, Aberdeen Angus, and Galloway. Cattle of these breeds are popular with farmers and ranchers in the western and central parts of the country where grass and corn are abundant. They are also scattered over many parts of the South and East where beef-raising is increasing.

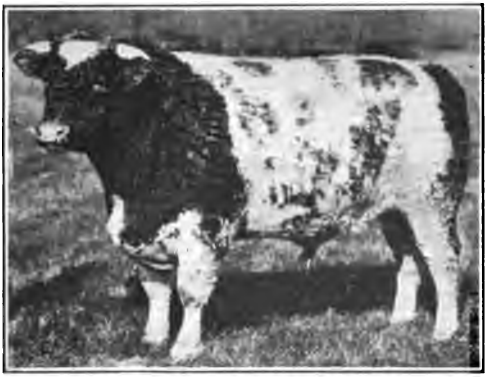

Fig. 134. — Shorthorn bull.

Shorthorn. — The most popular beef breed in the United States is the Shorthorn, or Durham (Fig. 134). More animals of this breed than of any other are found in this country and they are scattered over all parts. They

are the largest of any of the beef breeds, the bulls ranging in weight from 1800 to 2400 pounds and the cows from 1300 to 1600 pounds. The color may be red, red and white, white, or roan. The animals are fairly low-set, of good length, depth, and width, and the body is thickly fleshed.

Shorthorns are early maturing and fatten easily. The steers sell well as feeders and the meat is of high quality. The crosses of these cattle with other beef breeds and with scrubs result in very desirable beef animals. The Shorthorns are not as good rustlers for feed as those of some other breeds, but where grass is plentiful they will make beef faster than any other breed. They have been called the farmers' cattle, because they fit so well into conditions on general farms.

Fig. 135. — Polled Durham bull.

There are three important strains — the Booth, the Scotch, and the Bates. Booth and Scotch Shorthorns are true beef cattle, while the Bates Shorthorns are of the dual-purpose type.

Polled Durham. — The Polled Durhams are hornless Shorthorns. This breed is of recent origin and is becoming popular in many sections. Two divisions of this breed are the single-standard and the double-standard. The single-standard animals were developed by breeding hornless, or muley, cows of any breed to pure-bred Shorthorn bulls, then breeding any polled offspring to pure-bred Shorthorn bulls and continuing this crossing up to the fifth cross. The resulting animals were at least 96$\frac{7}{8}$ per cent Shorthorn blood and were eligible for registry

in the Polled Durham herd-book, but as they were not pure-bred Shorthorns they were not eligible for registry in the American Shorthorn herd-book. The double-standard animals were produced by breeding pure-bred Shorthorn hornless cows to pure-bred Shorthorn bulls. The resulting animals being pure-bred Shorthorns were eligible for registry in the American Shorthorn herd-book and being polled were also eligible to registry in the Polled Durham herd-book. In developing the breed, some breeders have inclined more toward the beef type and others toward the dual-purpose type with the result that the Polled Durhams are now somewhat variable. A good representative of the breed is shown in Fig. 135. Observe the general Shorthorn characteristics and the polled head.

FIG. 136. — Hereford cow.

Hereford.—In the United States the Hereford breed (Fig. 136) ranks second to the Shorthorn in numbers and its popularity is increasing. In weight they rank well with the Shorthorns, mature bulls averaging from 1800 to 2000 pounds and mature cows from 1200 to 1600 pounds. The animals are red with white markings, the color and markings being a distinguishing characteristic of the breed. The body is red, varying in different animals from a light to a dark shade; a rich medium red, not too dark, is most desired by breeders. The white markings are on the head and face with the white usually extending along the top of the neck and shoulders, on the throat, dew-

lap, underline, and legs. Also, a white switch on the tail is often found. The white face is so universal and so pronounced a character that the animals are often called "white faces." In conformation the body of the Herefords is broad, deep, compactly built and is set on short legs. The general appearance is that of a low, compact, blocky animal. The horns are longer and coarser than those of the Shorthorn; they are wide with waxy tips and curve outward, upward, and backward or outward and forward, or outward and downward. In bulls they are often drooping. The Hereford sometimes has a sloping rump and thighs lacking in depth and thickness. In recent years breeders have accomplished much to correct these faults. The hair is generally curly and of medium length, although short-haired animals are often seen. The animals are good rustlers for feed and are well adapted to range conditions. They cross well with native stock and have been largely used by cattlemen for improving range stock in the Southwest. They thrive in the South, cross fairly well with the native stock and are able to stand the heat and to subsist on the rather poor native pastures. They are also very popular in the corn-belt.

Polled Hereford. — A breed of cattle known as Polled Hereford has recently been developed. The breed was produced by selecting and breeding Herefords that showed polled characteristics. Pure-bred Polled Herefords are eligible for registry in the American Hereford herd-book and the American Polled Hereford record. They are the same as horned Herefords, except for the absence of horns.

Aberdeen-Angus. — The animals of the Aberdeen-Angus breed (Fig. 137) are hornless. They are usually smaller than the Shorthorns, mature bulls ranging from 2000 to 2200 pounds and mature cows from 1200 to 1600 pounds. The desired color is solid black. Red animals are sometimes found, but they are not popular with breeders. In conformation the Angus cattle differ from the Shorthorns and Herefords show-

ing more of a barrel-shaped, or cylindrical, body that is more compact and smooth. Notice the cylindrical shape of the animal shown in Fig. 137. The meat is fine-grained and of the highest quality; the breed has won repeatedly in the carcass tests at many live-stock shows. The animals are early maturing and fatten well when young and are popular for baby beef. They are not as good rustlers for feed as the Herefords and for this reason are less popular on the ranges. They are becoming popular in the South, ranking next to the Hereford in their adaptability to conditions in that section. They are found in large numbers in the corn-belt states.

Fig. 137. — Aberdeen-Angus cow.

Galloway. — Another black, hornless breed of cattle is the Galloway (Fig. 138). In weight they are less than the Angus, mature bulls ranging in weight from 1700 to 1900 pounds and mature cows, 1000 to 1300 pounds. The color is black with a brownish tinge. In conformation they are low-set and deep; the body is a little longer and much fatter in rib than the Angus and is covered with long, curly

Fig. 138. — Galloway bull.

hair. The head, like the body, is short and broad and is covered with long hair. The poll is flatter than that of the Angus and the ears are set farther back from the forehead. The Galloways are good rustlers, very vigorous, and are able to stand a cold climate. They have proved to be very valuable for use on the ranges of northwestern United States and western Canada, where they are now found in large numbers.

180. Breeds of dual-purpose cattle. — The chief dual-purpose breeds in the United States are certain strains of the Shorthorn, the Red Poll, and the Devon. Dual-purpose cattle are

FIG. 139. — Dual-purpose Shorthorns.

popular with farmers who keep a few cattle on which they depend for milk and butter for the family, and for offspring that will sell readily for beef. Since beef and dairy animals must be entirely different in type, it is impossible to produce a breed that will combine the functions of both and be superior for both purposes. However, it is possible for an animal to be a fair milker and at the same time produce calves that make good, but not the best, beef animals.

Dual-purpose Shorthorns. — The most popular cattle for

dual-purpose are the Shorthorns. Formerly most of the animals were of the Bates strain, but recently many of the Scotch strain have been used. Dual-purpose Shorthorn cows are longer in the legs, larger in the barrel, and thinner in the quarters than those of the beef type. The bulls approach the beef type more than do the cows. Calves from dual-purpose Shorthorns usually fatten well and make a good quality of beef. Fig. 139 shows a group of dual-purpose Shorthorn cows that have good milking qualities.

FIG. 140. — Red Poll cow.

Red Poll. — This is strictly a dual-purpose breed. In size the animals are smaller than most of the beef breeds, mature bulls weighing from 1700 to 2100 pounds and mature cows from 1100 to 1350 pounds. The color ranges from light to dark red, a deep, rich red being preferred by breeders. The animals are without horns, the head is lean and of medium length, the poll sharp and covered with a tuft of hair. The neck is longer and thinner than in the beef breeds. The chest is well developed and the ribs well sprung, but the body lacks the thick covering of flesh of strictly beef animals. The barrel is larger than in the beef breeds (a dairy characteristic) and the hindquarters are lighter fleshed. The udder is usually well developed, being more like that of dairy than of beef animals. This character is shown in Fig. 140. The breed is popular in Wisconsin, Iowa, Illinois, Ohio, Texas, Nebraska, and Michigan. As a breed they lack somewhat in uniformity.

Devon. — The Devon is one of the oldest breeds of cattle. The cows are good milkers and the steers are good for beef and

as oxen are unsurpassed. The Devon is not now especially popular in the United States, due probably to oxen not being used extensively as beasts of burden. In size the animals are smaller than Red Polls, mature bulls ranging in weight from 1500 to 2000 pounds and mature cows from 1100 to 1400 pounds. The color is solid red, a rich bright red being the most desired shade. In conformation the animals incline more toward the beef than the dairy type. The cows are fair milkers and, although the steers fatten more slowly than those of the beef breeds, they produce meat of good quality and fine texture.

181. Market classes and grades of beef cattle. — Variations in the weight, condition, quality, and age of the beef cattle sent to the live-stock markets make it necessary to establish different market classes and grades. Often, however, owing to the fluctuation in the supply and demand of cattle on the market, there is variation from day to day in the classes. For example, a lot of cattle one day might class as butcher stock and another day, when the demand for cattle was less, they might class as stockers and feeders. (See Table XIV.) Nevertheless, the classes are fairly distinct and breeders and feeders of beef cattle can, by studying the published market reports, keep familiar with market conditions. In Table XIV are given the market classes and grades of cattle on the Chicago market, as published in an Illinois Station bulletin by H. W. Mumford.

Beef cattle are steers ready for the block. (See Fig. 132.) They are in demand by exporters, packers, and shippers. Exporters usually send them to England, packers slaughter them for dressed beef, and shippers send them to some other live-stock market. Butcher stock includes cattle that have been "warmed up," a term used to designate cattle that have been on full feed only a short time and are not, therefore, in prime condition. It also includes the better grades of heifers, cows, and bulls that can be slaughtered for dressed beef. Canners are inferior animals that are used for canned meat. Cutters

TABLE XIV

MARKET CLASSES AND GRADES OF BEEF CATTLE

Beef cattle	Prime steers
	Choice steers
	Good steers
	Medium steers
	Common rough steers
Butcher stock . . .	Prime heifers
	Choice heifers
	Good heifers
	Medium heifers
	Prime cows
	Choice cows
	Good cows
	Medium cows
	Common rough steers
	Choice bulls
	Good bulls
	Medium bulls
Canners and cutters .	Good cutters
	Medium cutters
	Common cutters and good canners
	Medium canners
	Inferior canners
	Bologna bulls
Stockers and feeders .	Fancy selected feeders
	Choice feeders
	Good feeders
	Medium feeders
	Common feeders
	Inferior feeders
	Feeder bulls
	Fancy selected yearling stockers
	Choice yearling stockers
	Good yearling stockers
	Medium yearling stockers
	Common yearling stockers
	Inferior yearling stockers
	Good stock heifers
	Medium stock heifers
	Common stock heifers
Veal calves	Choice calves
	Good calves
	Medium calves
	Common calves
Milkers and springers	

are of a slightly better grade than canners and carry sufficient flesh to allow the loin and ribs to be sold over the butcher's block; the other parts of the carcass are used for canned meat. Feeders are animals intended for immediate use in the feed lot. Stockers are animals too young for immediate use as feeders; after attaining more growth they are placed in the feed lot. Veal calves are those of suitable age, condition, and weight to sell, when slaughtered, as veal. A milker is a cow in milk or one with a calf at her side. A springer is a cow advanced in pregnancy. Baby beef cattle include prime or choice steers between one and two years of age that have the desired beef conformation and show good killing quality.

182. Feeding of beef cattle. — As a business, the feeding of beef cattle is changing rapidly. Formerly feeders were grown on the western ranges and shipped to the corn-belt where they were fed for a time and then sold for beef. The western ranges are fast being settled by farmers and the large pastures are no longer available. As a result feeders from the Western States are becoming fewer in number. On many farms in the corn-belt states where a large proportion of the land is too rough for economical tillage, feeders can be raised advantageously. The southern farmer also has good opportunities for raising and fattening beef cattle and many are taking advantage of these conditions.

183. Rations for beef cattle. — Corn is the grain used largely in feeding beef cattle. It is supplemented by various by-product feeds. Stover and straw are largely used as roughage. Leguminous hays, including alfalfa, clover, and cowpeas, are often fed to the animals with good results. Silage also is used extensively. It saves grain in proportion to the amount of mature ears in the silage.

Rations will be affected, of course, by the feed available and by the purpose of the feeding — whether the cattle are being fattened or are being carried over the winter with no attempt to fatten them. Below are given some sample rations adapted

from Harper. They are based on a weight of 1000 pound animals and are fed in proportion to the weight of the animals:

Rations for Wintering Cattle

783 pound steer:
Shelled corn, 6 pounds
Clover hay, 19 pounds

767 pound steer:
Shelled corn, 4 pounds
Corn stalks, 9 pounds
Clover hay, 9 pounds

788 pound steer:
Cowpea hay, 20 pounds

743 pound steer
Silage, 44 pounds

707 pound steer:
Corn stalks, 20 pounds

Rations for Fattening Cattle

457 pound calves:
Shelled corn, 22 pounds
Cottonseed meal, 3 pounds
Clover hay, 12 pounds

534 pound calves:
Shelled corn, 18 pounds
Cottonseed meal, $2\frac{1}{2}$ pounds
Clover hay, 5 pounds
Corn silage, 18 pounds

854 pound yearling steers:
Shelled corn, 19 pounds
Cottonseed meal, $2\frac{1}{2}$ pounds
Clover hay, $4\frac{1}{2}$ pounds
Corn silage, 18 pounds

1010 pound steers:
Shelled corn, 16 pounds
Cottonseed meal, 3 pounds
Clover hay, 4 pounds
Corn silage, 15 pounds

979 pound steers:
Snapped corn, 10 pounds
Prairie hay, 12 pounds
Alfalfa hay, 10 pounds

893 pound steers:
Ear corn, 20 pounds
Clover hay, 10 pounds

Ward in Farmers' Bulletin 578 gives the following sample rations for 1000 pound steers when silage is to be fed:

Sample Rations with Silage

for the corn-belt

Ration 1

	Pounds
Corn silage	25
Corn stover	6
Cottonseed meal or oil meal	3
Shelled corn	14

Ration 2

Corn silage	25
Clover hay	7
Shelled corn	15

FOR THE EASTERN STATES WHERE HAY IS VERY HIGH AND CORN IS RELATIVELY HIGH

	Pounds
Corn silage	30
Corn stover	6
Cottonseed meal or oil meal	4
Shelled corn	10

FOR THE SOUTH WHERE COTTONSEED MEAL IS OF MODERATE PRICE AND COWPEA HAY IS RAISED ON THE FARM

Ration 1

	Pounds
Corn silage	35
Cowpea hay	8
Cottonseed meal or oil meal	7

Ration 2

	Pounds
Corn silage	30
Cottonseed hulls	12
Cottonseed meal	7

FOR THE WEST WHERE CORN CANNOT BE RAISED

Ration 1

	Pounds
Kafir silage	30
Prairie hay	3
Cottonseed meal	3
Kafir meal	10

Ration 2

	Pounds
Kafir silage	25
Alfalfa	7
Kafir grain	15

QUESTIONS

1. Define beef cattle, dairy cattle, dual-purpose cattle.
2. Describe the conformation of beef cattle.
3. Which is the most popular beef cattle breed?
4. The animals of which breed are especially good rustlers for feed?
5. Compare animals of the Galloway and Aberdeen-Angus breeds.
6. What is meant by baby beef cattle?
7. What feeds are most commonly fed to beef cattle?

8. Compare the rations for wintering cattle with those for fattening cattle.
9. Why is the Shorthorn called the farmers' cow?
10. Which beef breeds are popular in the South?

EXERCISES

1. **Scoring and judging beef cattle.** — Use the score-card given herewith, score and judge beef cattle. Follow directions and methods outlined for scoring horses as given on a previous page.

SCORE-CARD FOR BEEF CATTLE (FAT) [1]

Scale of Points	Points Deficient		
	Standard	Student's Score	Corrected
General appearance — 40 per cent:			
1. Weight, estimated ......lb.; actual ...... lb., according to age	10	.....	.....
2. Form, straight top and underline; deep, broad, low set, stylish, smooth, compact, symmetrical	10	.....	.....
3. Quality, fine, soft hair; loose, pliable skin of medium thickness; dense, clean, medium-sized bone	8	.....	.....
4. Condition, deep, even covering of firm, mellow flesh; free from patches, ties, lumps, and rolls; full cod and flank indicating finish	12	.....	.....
Head and neck — 7 per cent:			
5. Muzzle, broad, mouth large; nostrils large and open	1	.....	.....
6. Eyes, large, clear, placid	1	.....	.....
7. Face, short; jaw strong	1	.....	.....
8. Forehead, broad, full	1	.....	.....
9. Ears, medium size; fine texture	1	.....	.....
10. Neck, short, thick, blending smoothly with shoulder; throat clean with light dewlap	2	.....	.....
Forequarters — 9 per cent:			
11. Shoulder vein, full	1	.....	.....
12. Shoulders, smoothly covered, compact, snug, neat	4	.....	.....
13. Brisket, trim, neat; breast full	2	.....	.....
14. Legs, wide apart, straight, short; arm full; shank fine	2	.....	.....

[1] From Purdue University Extension Circular No 29.

SCORE-CARD FOR BEEF CATTLE (FAT) (*Continued*)

Scale of Points	Points Deficient		
	Standard	Student's Score	Corrected
Body — 30 per cent:			
15. Chest, full, deep, wide; girth large; crops full	4	.....	.....
16. Ribs, long, arched, thickly and smoothly fleshed	8	.....	.....
17. Back, broad, straight, thickly and smoothly fleshed	8	.....	.....
18. Loin, thick, broad	8	.....	.....
19. Flank, full, even with underline	2	.....	.....
Hindquarters — 14 per cent:			
20. Hips, smooth	1	.....	.....
21. Rump, long, wide, level; tail-head smooth; pin-bones wide apart, not prominent	3	.....	.....
22. Thighs, deep, full	4	.....	.....
23. Twist, deep, plump	4	.....	.....
24. Legs, wide apart, straight, short; shanks fine, smooth	2	.....	.....
Total	100	.....	.....

2. **The cuts of beef and veal.** — An important study in agriculture is the disposition of the carcass after the animals are slaughtered for meat. Many facts about this matter can be learned by visiting a local packing house or butcher shop. Bulletin 147 by the University of Illinois is a very excellent treatment of this subject. It contains about one hundred fifty pages and seventy-five illustrations from original carcasses and cuts of meat and it shows the Chicago method of cutting meat. It is not distributed except to persons especially interested in the subject, but an abstract of the bulletin is for general use and distribution. By explaining to the Director of the station the use that will be made of the bulletin the teacher can undoubtedly secure a few copies of the complete pamphlet for reference and enough copies of the abstract for class use.

Teachers should arrange with a packer or a butcher to take the class to his place of business. Usually these men are willing to aid in teaching about the cuts of meat. In some sections the local butchers do not follow the Chicago method of cutting beef; however, the methods will not differ very materially. In which part of the carcass are the expen-

sive cuts? The cheaper cuts? Compare the price of porterhouse steak with flatrib cuts at your local market. Which are the best rib cuts? How many porterhouse steaks in a carcass? Why does a butcher like a beef animal to be in good condition?

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CHAPTER XVII

DAIRY CATTLE

Conformation of dairy cattle.
Breeds of dairy cattle.
    Jersey, Guernsey, Holstein-Friesian, Ayrshire, Dutch Belted, Brown Swiss.
The dairy calf.
    Teaching a calf to drink.
    Kind of milk for calves.
    Grain and hay for calves.
    Sanitation in calf pens.
Feeding dairy cows in summer.
    Cows on pasture.
    Soiling crops and silage for summer feeding.
Feeding dairy cows in winter.
    Succulent feeds for winter.
    Dry roughages for winter.
    Concentrates in the ration.
    Quantities of grains and roughages to feed.
Water and salt for cows.
Stables for dairy cows.
    Light.
    Ventilation.
    Convenience of arrangement.
    Floors.
    Ties for the cattle.
    A modern sanitary dairy stable.

THE breeds of dairy cattle have been highly developed. They are specialized for the production of milk and butter-fat. The dairy cow is a marvelous organism. We feed her grain, by-products of the factory, silage, hay, and in return she yields us milk in enormous quantities and of high nutritive value.

There are records of 27,000 and 30,000 pounds of milk a year from a single cow, yielding milk of many times her own weight. There are also recorded yields of 1200 pounds of butter-fat in a year, equivalent to about 1500 pounds of butter. With such high production, it is to be expected that the animal requires the best of feed and care, and comfortable, well lighted, sanitary stables. Great progress has been made in recent years in the care and housing of the dairy cow.

184. Conformation of dairy cattle. — The larger number of dairy cows that secrete large quantities of milk have a distinctive conformation, and animals possessing this are said to be of the dairy type. Two prominent features of this type are spareness of frame and a wedge-shaped body. The spare frame is not due to disease or lack of feed, but, on the contrary, to the tendency of the animals to convert feed into milk and not into body fat. In a cow of good conformation three wedges are present. The first is seen when the animal is viewed from the side, as shown in Fig. 141. The wedge is not formed by lack of chest depth, but by proper chest depth together with extreme depth of the rear of the barrel and largeness of the udder. The second wedge is seen when the cow is viewed from the front. The apex of the wedge is at the withers and the base at the floor of the chest. The third wedge is seen when the animal is viewed from above. The apex is at the withers and the base, from one hip point to the other. An animal having the three-wedge shape has abundant abdominal and chest

FIG. 141. — Dairy cow, showing wedge-shape form; side view.

capacity and udder development. Note Fig. 142, the external parts of the dairy cow.

185. Breeds of dairy cattle. — The chief breeds of dairy cattle raised in the United States are Jersey, Guernsey, Holstein-Friesian, and Ayrshire. Secondary breeds are Dutch Belted and Brown Swiss. All of these dairy breeds originated in Europe.

Jersey. — The Jersey breed originated on the Island of Jersey, which lies in the English channel about thirteen miles

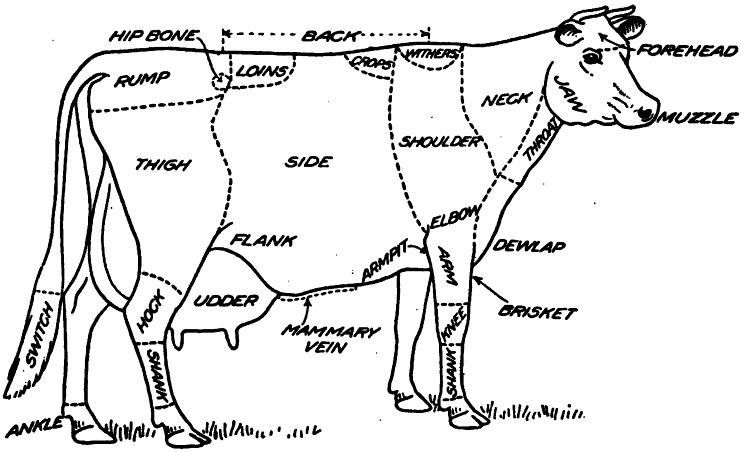

FIG. 142. — Points of the dairy cow.

from the coast of France. It is thought that the foundation stock was from Normandy and Brittany. These early cattle were rough and not developed in the milk-giving quality, but from this foundation has been developed an excellent breed of cattle. In 1779 a law was passed prohibiting the importation of cattle into Jersey and this law has always been rigidly enforced, with the result that the cattle have been purely bred for more than a century.

Jerseys have been imported to a large extent into the United States and have increased in number so rapidly and have proved

so well adapted to the wide range of climate conditions that they are to be found in large numbers in all parts of the country.

The Jerseys are the smallest of the chief dairy breeds, the cows averaging in weight from 700 to 1000 pounds and the bulls from 1200 to 1800 pounds. The color is variable, ranging through all shades of brown and black, and various shades of fawn, yellow, red, and brindle. With the colors there may or may not be present large or small patches of white; those animals showing white patches are known as broken-colored and those without, as solid-colored animals. Characteristics usually present in Jerseys are a black muzzle, which is surrounded by a ring of light-colored skin and hair, a black tongue, and a black switch.

Fig. 143. — Jersey cow, Eminent's Bess, 209,719. Yearly record, 18,781 pounds, 15.6 ounces milk testing 962 pounds, 13.2 ounces fat equal to 1132 pounds, 12 ounces butter.

In their native home the Jerseys have been bred for high butter production and not for high milk yield. American breeders have accomplished much toward increasing the milk yield and at the same time have kept up the percentage of fat in the milk. As found in America to-day, the Jersey gives a moderate quantity of milk that is rich in fat, averaging about 5 per cent; in the quantity of butter that can be made from the milk, she ranks very high. Fig. 143 shows Eminent's Bess, a high-yielding Jersey cow. Study the Jersey characteristics of this animal.

Guernsey. — Guernsey, one of the Channel Islands, is the native home of this breed. The original stock, like that of Jersey, came from the mainland of France and has been developed by careful breeding and selection of the animals. The

policy of excluding all outside cattle has existed in Guernsey as in Jersey, with the result that the purity of the animals is unquestioned.

There have been fewer importations of Guernseys into the United States than of Jerseys; nevertheless the animals are found in all parts of the country and their popularity is increasing rapidly. In size the cattle are somewhat larger than Jerseys, mature cows averaging about 1050 pounds, and bulls, about 1500 pounds. Often the cows will weigh 1200 pounds. Yellow and orange with large patches of white are the predominating colors, but darker shades approaching brown are sometimes found, especially on bulls. The muzzles are nearly always buff or flesh-colored surrounded by light-colored hair. A characteristic of the breed is a secretion of a yellow coloring matter from the skin, which is especially noticeable in the ears, around the eyes, and about the udder. In quantity and richness of milk, Guernseys are similar to Jerseys, giving a moderate quantity relatively rich in butter-fat. The milk is more yellow than that of the Jerseys, which is a desirable quality, especially in market milk, as it gives the product an appearance of richness much desired by consumers. Dairymen who supply whole milk often have at least a few pure-bred or high-grade Guernseys in their herds because of this yellow color of the milk. In the quantity of butter that can be made

Fig. 144. — Guernsey cow, Johanna Chêne, 30,889. As a three-year-old, she produced 16,186.70 pounds milk testing 863.36 pounds fat.

from the milk, the animals rank with the Jerseys. Fig. 144 shows a well known Guernsey cow, Johanna Chêne.

Holstein-Friesian. — The breed of black-and-white cattle known as the Holstein-Friesian originated in North Holland and Friesland where they have been purely bred for two thousand years or more. The dairy industry in Holland has been highly developed and the cattle have always been well cared for and fed abundantly.

Many importations have been made into the United States and the animals have increased rapidly in number. They are now found in all parts of the country, but more especially in dairy regions where high yield of milk is desired. In size the animals are the largest of the dairy breeds; mature cows often weigh 1500 pounds and seldom less than 1200 pounds; mature bulls often go above 2500 pounds.

Fig. 145. — Holstein-Friesian cow, Dutchess Skylark Ormsby, 124,513. World's record cow, 1915. Butter-fat made in one year, 1205.091 pounds.

The frame of the animal is very large. Their color is strongly marked black and white with the two colors in separate irregular patches. In some animals the black predominates and in others, the white. In milk production Holstein cows excel those of all other breeds. The butter-fat percentage, however, is small, but with the large quantities of milk, the total butter-fat during a definite period of time often equals and in many cases exceeds that from animals of other breeds. The color of the milk is somewhat bluish and the butter-fat is rather soft and of a

whitish color in contrast to the yellow butter-fat of the Jerseys and the Guernseys. Holstein milk is sometimes discriminated against by consumers on account of its color and lack of richness, but dairymen overcome these objections by having in the herd a few Jersey and Guernsey cows. The cut, Fig. 145, is of Dutchess Skylark Ormsby, the Holstein cow that made the world's record of all breeds for butter-fat in 1915. Her record for the year is 1205.091 pounds of fat. This would make more than 1500 pounds of butter. Her record for milk is 27,760 pounds. The milk from the farm where she is owned sold for 10 cents a quart, which means about $1388 for the product.

Ayrshire. — The native land of the Ayrshire breed (Fig. 146) is the County of Ayr in the southwestern part of Scotland.

Fig. 146. — Prize-winning Ayrshire cows at Panama Exposition, 1915.

The animals have been developed by selection and breeding of the native cattle of the country with a probable admixture of the blood of the other dairy and beef breeds of England. Importations of these cattle into the United States have been made from time to time, but the animals are not so numerous as those of the other dairy breeds. However, many herds are to be found, especially in New York and New England as well as scattered over other parts of the country. The cattle are of medium size, the cows weighing from 900 to 1100 pounds at maturity and the bulls from 1400 to 1800 pounds. The most common color is red and white spotted, with white predominating. In quantity of milk the Ayrshires rank next to the Holsteins; in butter-fat the milk averages 3½ to 4 per

cent. The fat globules of the milk are small and do not separate freely from the milk, and the cream has little color. The milk is, therefore, better suited for use as whole milk than for butter-making. It is stated to be especially desirable for invalids and is often sold to hospitals.

Dutch Belted. — Like the Holsteins the Dutch Belted cattle originated in Holland, where they are known as the Lakenfield cattle. These cattle have never become numerous in the United States, although scattered herds are found in all of the principal dairy districts. The animals are of medium size, mature cows averaging about 1000 pounds and mature bulls about 1500 pounds. The color is black and white, a broad belt of white encircling the body about the middle, with the other parts of the body a jet black. In milk production the animals are fair, but the quality is not up to the average.

Brown Swiss. — The native home of these cattle is the Canton Schwyz in Switzerland, where the breed has been developed for dairy purposes from the native cattle found there. Scattered herds are found in the United States and where they have become known the animals have made a favorable impression for dairy purposes. The cattle are of medium size, mature cows weighing from 1200 to 1400 pounds and mature bulls as high as 1800 pounds and over. The color is a grayish brown, usually darker on the head, the neck, legs, and hindquarters, shading lighter on the body. Characteristic markings are a mealy band around the muzzle, a light stripe across the lips and up and down the sides of the nostrils, a light-colored tuft of hair between the horns, and a light-colored stripe on the back and tail. As milk-producers they rank with the average, many, however, making very good individual records. The average percentage of fat in the milk is 3½ to 4.

186. The dairy calf. — The calf requires the milk of the mother for the first few days after birth. The milk, which at this time is called colostrum, is very different in composition from normal milk and performs a necessary function

in acting as a purgative to rid the calf's body of unnecessary matter. The milk remains abnormal for about three or four days. Usually the calf is left with its mother during this period.

Teaching a calf to drink. — After the calf has been removed from the mother, it must be taught to drink milk from a pail. It is well to have the calf hungry when about to give it a lesson. In nursing, the calf's head is up and in drinking from a pail, it is down. It must, therefore, be taught to drink with its head down and the animal must be held. The usual plan is to place a quart or so of milk in a pail, back the calf into a corner of the yard or stall, straddle its neck, put your finger in its mouth, and hold the head down so that the mouth is in the milk. The calf will suck the finger for a time, but will soon learn to drink the milk. For the first four days, the calf should be fed three times a day; after this, twice a day is often enough. How much to feed varies somewhat with the weight of the calf. One weighing about sixty-five pounds or less should have at the start about six or eight pounds of milk a day and larger calves in proportion. Care should be taken not to overfeed a calf. The milk must be clean and warm. Indigestion and calf scours are very likely to result if cold milk is fed. A temperature 100° F. is about right.

Kind of milk for calves. — A calf should have whole milk for at least ten days, after which it may be fed skim-milk. The change from whole- to skim-milk should be made gradually. The first day substitute a half pound of skim-milk for a half pound of whole milk and keep this up for three days, then increase a pound and a half a day until no more whole milk is fed. A calf receiving skim-milk does not get enough fat in its feed and to overcome the deficiency dairymen add fat to the milk. Usually this fat is from linseed meal, a product rich in this material. A mush is made by mixing the meal with hot water. For the first day a tablespoonful is given, after which the quantity is increased up to three or four tablespoonfuls.

When the calf has learned to eat grain, as described later, the mush need not be fed.

Grain and hay for calves. — While the change from whole- to skim-milk is taking place, the calf should be taught to eat grain and hay. A feed box should be provided and a small quantity of grain placed in it. At first it may be necessary to rub a little grain on the calf's mouth to induce it to eat, but soon it will learn to take the grain regularly. The box must be kept clean and any grain not eaten must be removed to prevent it from becoming sour. Ground oats with the hulls sifted out, ground corn, or a mixture of the two may be fed.

The grain ration for the calf up to the time it is six months old may be the one described above, or some additional feed may often be given to advantage. A good grain mixture is three parts ground oats, three parts ground corn, one part wheat bran, one part linseed meal. At first what can be picked up in the hand is sufficient and the amount should be increased as the calves will eat it up clean. At two months of age a calf should eat about a pound of grain a day and at six months, about three pounds.

Hay should be fed at the same time that the grain is given. Fine clean alfalfa or clover hays are good for this purpose.

Sanitation in calf pens. — The quarters where calves are kept must be clean; otherwise disease is almost sure to occur. Clean bedding must be used and the pens cleaned frequently. It is also necessary to disinfect them occasionally. Whitewash, crude carbolic acid, and proprietary stock dips are good disinfectants for this purpose. It is well to spray carbolic acid on the walls of the pens and follow this by a coat of whitewash. Many of the proprietary preparations, such as kreso, lysol, and creolin, are good disinfectants. They may be purchased from druggists. It is not so important which disinfectant is employed, but that it is used often enough to keep the pens sanitary.

187. Feeding dairy cows in summer. — Summer and winter feeding of dairy cows involve different problems. In summer pasturage and soiling crops are available and thus the cows can obtain abundant succulent feed, while in winter they are confined to stalls and as fresh grass and soiling crops are not in season, they must be supplied succulent feed in some other way.

Cows on pasture. — Grass is conducive to medium production, but, even with the best pastures, supplementary feeds are necessary for the highest production. For medium production, grass will supply all the food necessary, as it is practically a balanced ration for dairy cows. Supplementing pastures with grain is sometimes advisable. Eckles of the Missouri Station suggests the following for cows of the different breeds:

Jersey cow producing —	
20 pounds of milk daily	3 pounds of grain
25 pounds of milk daily	4 pounds of grain
30 pounds of milk daily	6 pounds of grain
35 pounds of milk daily	8 pounds of grain
40 pounds of milk daily	10 pounds of grain
Holstein-Friesian or Ayrshire cow producing —	
25 pounds of milk daily	3 pounds of grain
30 pounds of milk daily	5 pounds of grain
35 pounds of milk daily	7 pounds of grain
40 pounds of milk daily	9 pounds of grain
50 pounds of milk daily	10 pounds of grain

Concerning these quantities and the rule of feeding, the Dairy Division of the United States Department of Agriculture says:

> While this is, of course, an arbitrary rule and variations should be made to suit different conditions and individual cows, it is in accord with good feeding practice and probably is as good a rule of its kind as has been formulated.

As grain mixtures for this purpose, the Dairy Division suggests the following:

Mixture No. 1:	
Ground oats	100 pounds
Wheat bran	100 pounds
Corn meal	50 pounds
Mixture No. 2:	
Wheat bran	100 pounds
Corn meal	100 pounds
Cottonseed meal	25 pounds
Mixture No. 3:	
Corn-and-cob meal	250 pounds
Cottonseed meal	100 pounds
Mixture No. 4:	
Wheat bran	100 pounds
Gluten feed	50 pounds
Corn meal	50 pounds

Soiling crops and silage for summer feeding. — When pastures become short, dairymen often resort to the use of soiling crops to supply the green feed. For this purpose, second-growth red clover, field peas, or alfalfa give excellent results. The advantages of soiling crops are chiefly two: large quantities of forage can be grown on a relatively small area and the crops are palatable and succulent. One disadvantage is the large amount of labor necessary to harvest and feed the crops. A succession of crops must be planned in order that green feed be available continuously.

With a silo for use in summer, the dairyman has a supply of succulent feed that is easily handled and that has been prepared the previous fall at a minimum of expense compared with soiling crops. The use of silage as summer feed for dairy cows is increasing.

188. Feeding dairy cows in winter. — In winter feeding, some important factors are to furnish a supply of abundant succulent feed, to use home-grown feeds as far as available and economical, and to consider the cost of all feeds carefully in order to make a profit.

Succulent feeds for winter. — Silage and roots are depended on for succulence during the winter. Of the two, silage is the most used. Among the reasons for the popularity of silage

for feeding dairy cows, Woodward of the United States Department of Agriculture gives the following:

1. Silage is the best and cheapest form in which a succulent feed can be provided for winter use.
2. An acre of corn can be placed in the silo at a cost not exceeding that of shocking, husking, grinding, and shredding.
3. Crops can be put into the silo during weather that could not be utilized in making hay or curing fodder; in some localities this is an important consideration.
4. A given amount of corn in the form of silage will produce more milk than the same amount when shocked and dried.
5. There is less waste in feeding silage than in feeding fodder. Good silage properly fed is all consumed.
6. Silage is very palatable.
7. Silage, like other succulent feeds, has a beneficial effect upon the digestive organs.
8. More stock can be kept on a given area of land when silage is the basis of the ration.
9. On account of the smaller cost for labor, silage can be used for supplementing pastures more economically than can soiling crops, unless only a small amount of supplementary feed is required.
10. Converting the corn crop into silage clears the land and leaves it ready for another crop sooner than if the corn is shocked and husked.

From 30 to 40 pounds of silage is the usual quantity fed. The rations listed below, which are given by Woodward, have been found to be satisfactory. For grain mixtures, see the subsequent pages.

For a 1300-pound cow yielding 40 pounds of milk testing 3.5 per cent:

	Pounds
Silage	40
Clover, cowpea, or alfalfa hay	10
Grain mixture	10

For the same cow yielding 20 pounds of 3.5 per cent milk:

	Pounds
Silage	40
Clover, cowpea, or alfalfa hay	5
Grain mixture	5

For a 900-pound cow yielding 30 pounds of 5 per cent milk:

	Pounds
Silage	30
Clover, cowpea, or alfalfa hay	10
Grain mixture	11

For the same cow yielding 15 pounds of 5 per cent milk:

	Pounds
Silage	30
Clover, cowpea, or alfalfa hay	8
Grain mixture	5

The quantity of nutrients grown to the acre in root-crops is small compared to the cost of production. However, they have an advantage over silage for small herds because a small quantity can be preserved and fed each day, whereas with silage a certain minimum number of cows must be kept in order to make it practicable, since enough silage must be removed from the silo each day to prevent excessive fermentation. As to the choice of root-crops to grow for this purpose, mangels furnish a desirable feed for the cows and make the greatest yield. Other kinds of beets and carrots are, also, good feeds. Turnips may be fed, but always after milking, as they impart a bad flavor to the milk if fed immediately before milking.

Dry roughages for winter. — The best dry roughages for dairy cows to be fed in connection with silage or roots are hays from legumes such as alfalfa, red clover, crimson clover, alsike clover, cowpeas, soybeans, or field peas (grown with oats). These hays add a large proportion of protein to the ration and to use them cuts down the cost of this ingredient. Corn stover, grass, or grain hays are often fed to dairy cows, especially when the crops can be grown on the farm where fed, but as these roughages are low in protein, the deficiency must be supplied by the use of high-protein concentrates. The usual quantity of dry roughage fed is from eight to ten pounds a day, in addition to the silage.

Concentrates in the ration. — A cow cannot eat enough roughage to supply all the nutrients necessary for a maximum flow of milk; consequently concentrates in the form of grain

or factory by-products must be added to the ration. The grains most commonly fed are corn, oats, barley, and rye. The by-products used extensively are wheat bran, wheat middlings, linseed meal, cottonseed meal, gluten meal, gluten feed, hominy feed, brewers' grains, malt sprouts, distillers' grains, beet-pulp, molasses, buckwheat middlings, cocoanut meal, and peanut meal.

In making up a grain mixture for the cattle, many factors must, of necessity, be considered. A few simple rules and directions and a number of grain mixtures as given by the Dairy Division of the United States Department of Agriculture are printed herewith:

1. Make up the mixture to fit the roughage available. With roughage entirely of the low-protein class the grain should contain approximately from 18 to 22 per cent of protein, while with exclusively high-protein roughage the grain ration need contain only about 13 to 16 per cent.
2. Select grains that will furnish the various constituents, especially protein, at the least cost, using home-grown grains if possible.
3. Be sure that the mixture is light and bulky.
4. The mixture should be palatable.
5. See that the grain has the proper physiological effect upon the cow.

Samples of Grain Mixtures to Be Fed with Various Roughages

WITH LOW-PROTEIN ROUGHAGES

Adapted to be fed with corn silage, corn stover, timothy, prairie, rowen, or millet hays, cottonseed hulls, etc.

Mixture 1. — Per cent of digestible protein, 18.4:
- 500 pounds corn meal.
- 400 pounds dried distillers' grains (corn).
- 200 pounds gluten feed.
- 300 pounds old process linseed meal.

Mixture 2. — Per cent of digestible protein, 19.8:
- 100 pounds corn meal.
- 100 pounds cottonseed meal.
- 100 pounds old process linseed meal.
- 200 pounds wheat bran.

Mixture 3. — Per cent of digestible protein, 19.1:
- 200 pounds of barley.
- 200 pounds cottonseed meal.
- 100 pounds alfalfa meal.
- 100 pounds wheat bran.

Mixture 4. — Per cent of digestible protein, 18.1:
- 200 pounds corn meal.
- 100 pounds cottonseed meal.
- 100 pounds ground oats.
- 100 pounds old process linseed meal.

WITH HIGH-PROTEIN ROUGHAGES

Adapted to be fed with clover, alfalfa, soybeans, cowpea, vetch, or other legume hay.

Mixture 5. — Per cent of digestible protein, 14.1:
- 400 pounds corn meal.
- 100 pounds cottonseed meal.
- 100 pounds gluten feed.
- 100 pounds wheat bran.

Mixture 6. — Per cent of digestible protein, 14.9:
- 200 pounds corn meal.
- 200 pounds gluten feed.
- 100 pounds malt sprouts.
- 100 pounds wheat bran.

Mixture 7. — Per cent of digestible protein, 13.7:
- 100 pounds of barley.
- 200 pounds cocoanut meal.
- 100 pounds ground oats.
- 100 pounds wheat bran.

Mixture 8. — Per cent of digestible protein, 15.8:
- 300 pounds corn-and-cob meal.
- 200 pounds gluten feed.
- 100 pounds cottonseed meal.
- 100 pounds wheat bran.

WITH COMBINATION OF HIGH- AND LOW-PROTEIN ROUGHAGES

Adapted to be fed with silage and clover or other legume hay; corn stover and clover or other legume hay; mixed hay, or oat and pea hay and the like.

Mixture 9. — Per cent of digestible protein, 16.3:
- 400 pounds corn meal.
- 300 pounds dried distillers' grains (corn).
- 100 pounds gluten feed.
- 100 pounds old process linseed meal.

Mixture 10. — Per cent of digestible protein, 16.1:
- 300 pounds corn meal.
- 100 pounds cottonseed meal.
- 100 pounds old process linseed meal.
- 200 pounds wheat bran.

Mixture 11. — Per cent of digestible protein, 16.7:
- 200 pounds corn meal.
- 100 pounds peanut meal (with hulls).
- 100 pounds cottonseed meal.
- 100 pounds wheat bran.

Mixture 12. — Per cent of digestible protein, 16.4:
- 100 pounds corn meal.
- 100 pounds ground oats.
- 100 pounds cottonseed meal.
- 100 pounds wheat bran.

The mixtures which contain linseed meal are particularly adapted for use when no succulence is in the ration.

Quantities of grains and roughages to feed. — The grain ration should be fed in proportion to the quantity of fat or milk produced by the cow. A good rule to follow is to feed one pound of grain a day for every pound of butter-fat produced during the week. Another method is to feed one pound of grain to each three pints, or three pounds, of milk produced daily by the cow, except in case of a cow producing forty pounds or more of milk, when one pound to each three and one-half or four pounds, or pints, of milk is fed. Usually a cow should be fed all the roughage she will eat up clean. If, however, she starts to become fat, the quantity should be lessened.

These rules serve only as guides and should be modified according to the capacities of the animals to convert the feed into milk.

189. Water and salt for cows. — The milking cow requires much water. About 87 per cent of cow's milk is water. The water should be pure; stale water is distasteful to the animal and she will not drink enough for a maximum milk production. When cows are stabled and do not have access to running water, they should be watered two or three times a day.

More than most animals, the dairy cow requires abundant

salt. It is a good plan to place an ounce in the feed each day and also to have rock salt in boxes in the yard where she can lick it as wanted. If a cow obtains abundant salt, she will drink much water, which, as stated above, is an advantage.

190. Stables for dairy cows. — If a cow is to produce the maximum quantity of milk, she must be kept in clean, comfortable quarters. The essentials of such quarters are that they have plenty of light, plenty of fresh air with no drafts, be convenient for the attendants, and have a floor that can be kept clean. This does not mean that the stables must be

Fig. 147. — Dairy barn plentifully supplied with windows.

expensive, because good practicable stables embodying these features can and are built at a relatively low cost.

Light. — It is almost impossible to have too many windows in a cow stable. There should be at least four square feet of window-space for each animal. Sunlight is an enemy to bacteria, which are responsible for unhealthful, impure milk and many diseases of the cattle. In the stable plentifully supplied with light, it is easy to see dirt that accumulates and get rid of it. In Fig. 147 is shown a modern dairy stable plentifully supplied with windows.

Ventilation. — When the windows can be kept open, the stable can be ventilated through them, but in cold climates

when the windows cannot be kept open in the winter, a system of intakes and outtakes must be employed to provide fresh air. In the stable shown in Fig. 147, the fresh air is taken in through openings in the side walls between the windows and carried through flues to the ceiling in front of the cattle. The foul air passes out through flues that open near the floor and is carried to the outside through the ventilators on the roof.

Convenience of arrangement. — In a dairy stable, convenience is of prime importance, for the work can then be efficiently

Fig. 148. — A modern sanitary dairy barn. Milk from a barn like this is very likely to be clean.

and economically carried on. The feed should be accessible, the stalls should be placed in rows so that feeding and other operations are conveniently accomplished, and pure, fresh, running water should be, if possible, piped to the mangers in front of the cattle.

Floors. — Concrete floors are the best for dairy stables; they are easy to keep clean and are sanitary. The floors of the stalls may be of some softer material, like wooden blocks or cork brick, but, if plenty of bedding is used under the cattle, stall floors of concrete are satisfactory.

Ties for the cattle. — Stanchions are the best kind of ties for cattle; they are preferable to a rope and halter. Many good metal and wooden stanchions are for sale by dealers in stable equipment.

A modern sanitary dairy stable. — An interior view of a modern sanitary stable, built by the Government at the Naval Academy, is shown in Fig. 148. Notice the concrete floor, the cork brick in the stalls, the metal stanchions, the feed trough in front of the stalls, and the large number of windows. Stables like this fulfill all the requirements for the production of sanitary milk.

QUESTIONS

1. What is meant by the term dairy form?
2. Locate the three wedges of a dairy cow.
3. Discuss the milk-giving qualities of the four chief breeds of dairy cattle.
4. Which two breeds give the highest percentage of butter-fat?
5. What is colostrum and what is its function?
6. How can a calf be taught to drink milk from a pail?
7. Why should milk that is fed to calves be warm?
8. With what grains can pastures for dairy cows be supplemented?
9. Why is silage a popular succulent dairy feed?
10. Why should a dairy barn be well supplied with windows?

EXERCISES

1. **Scoring and judging dairy cows.** — Using the score-card for dairy cattle printed herewith, score and judge several cows. Follow the method outlined for scoring and judging horses in a previous chapter. Whenever you see a dairy cow notice her good and her bad points.

It is well to mention here that dairy type alone cannot be depended on in selecting or judging cows for production. The only way to have an accurate knowledge of the milk-giving quality of an animal is to keep a record of the milk she gives. It is true, however, that dairy type, which is the type described on a dairy score-card, generally accompanies a larger milk-giving quality, but this is not always the case as shown by the following:

"That the appearance of a dairy cow cannot be depended on to indicate her production of milk is illustrated by a demonstration con-

ducted under the auspices of the Dairy Division of the Department with a herd of nine cows at the National Dairy Show held in 1916 at Springfield, Mass.

"A year's record of milk and butter-fat already had been made for all the cows of the herd. During the show, complete records of production and feed consumption were kept and in every case the previous records were duplicated. Some of the cows were of poor dairy type, yet were good producers; others were of good dairy type, yet were poor producers; still others of similar appearance had greatly different records. Of the last-named class were Nos. 8 and 9. Many experienced stockmen selected No. 9 as the better of the two, but the records showed that for the last year No. 8 gave 8,445 pounds of milk and 346 of fat compared with 4,279 pounds of milk and 198 of fat for No. 9. This served as an object lesson that good dairy type is not always associated with large production and that poor dairy type does not indicate lack of large yield." From *Weekly News Letter* published by the United States Department of Agriculture.

Score-card for Dairy Cattle[1]

Breed.................... Name..........................

General appearance. — A dairy cow should weigh not less than 800 pounds, have large capacity for feed, a dairy temperament, well developed milk organs, fine quality and perfect health, and be capable of a large production of milk and butter-fat.

Points	Perfect	Scorer's	Corrected
Indication of capacity for feed, 25 points:			
Face, broad between the eyes and long; muzzle, clean-cut; mouth, large; lips, strong; lower jaws, lean and sinewy	5	.....	.....
Body, wedge shape as viewed from front, side, and top; ribs, long, far apart, and well sprung; breast, full and wide; flanks, deep and full	10	.....	.....
Back, straight; chine, broad and open; loin, broad and roomy	5	.....	.....
Hips and thurls, wide apart and high	5	.....	.....
Indication of dairy temperament, 25 points:			
Head, clean-cut and fine in contour; eyes, prominent, full, and bright	3	.....	.....

[1] From U. S. Dept. of Agriculture Bulletin 281.

SCORE-CARD FOR DAIRY CATTLE (*Continued*)

POINTS	PERFECT	SCORER'S	COR-RECTED
Neck, thin, long, neatly joined to head and shoulders, and free from throatiness and dewlap	4	.....	.....
Brisket, lean and light	2	.....	.....
Shoulders, lean, sloping, nicely laid up to body; points, prominent; withers, sharp	4	.....	.....
Back, strong, prominent to tail head, and open jointed	3	.....	.....
Hips, prominent, sharp, and level with back	3	.....	.....
Thighs, thin and incurving	4	.....	.....
Tail, fine and tapering	1	.....	.....
Legs, straight; shank, fine	1	.....	.....
Indication of well developed milk organs, 25 points:			
Rump, long, wide, and level; pelvis, roomy	3	.....	.....
Thighs, wide apart; twist, high and open	3	.....	.....
Udder, large, pliable, extending well forward and high up behind; quarters, full, symmetrical, evenly joined, and well held up to body	15	.....	.....
Teats, plumb, good size, symmetrical, and well placed	4	.....	.....
Indications of strong circulatory system, health, vigor, and milk flow, 25 points:			
Eyes, bright and placid	2	.....	.....
Nostrils, large and open	3	.....	.....
Chest, roomy	5	.....	.....
Skin, pliable; hair, fine and straight; secretions, abundant in ear, on body, and at end of tail	7	.....	.....
Veins, prominent on face and udder; mammary veins, large, long, crooked, and branching; milk wells, large and numerous	7	.....	.....
Escutcheon, wide and extending high up	1	.....	.....
Total	100	.....	.....

Remarks...

Name of scorer........................ Date................

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CHAPTER XVIII

DAIRYING

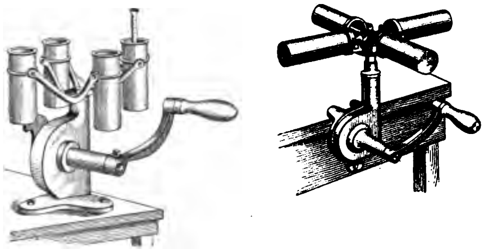
Composition of milk.
Testing of milk for fat.
Separation of cream from milk.
Bacteria in milk.
Production of sanitary milk.
    Keeping foreign matter out of the milk.
    Kind of utensils for milk.
    Care during the milking.
    Care of milk in the milk house.
Pasteurization of milk.

The dairy industry is one of the most important divisions of agriculture. One has but to visit a milk-receiving station in any of the large cities and see train after train of milk coming to the market to realize something of the magnitude of dairying as now conducted. When we consider the vast quantities of butter, cheese, ice cream, and condensed milk that are consumed, we comprehend still more the extent of the industry. It is all the more unfortunate, therefore, that much of the milk is produced under unsanitary conditions, and it is this aspect of the subject that is stressed in the ensuing chapter.

191. Composition of milk. — The average composition of milk as determined by more than five thousand analyses made by the New York State Experiment Station at Geneva, is as follows:

Water		87.1 per cent
Butter-fat		3.9 per cent
Protein	Casein	2.5 per cent
	Albumin	.7 per cent
Milk-sugar		5.1 per cent
Ash		.7 per cent
Total		100.0 per cent

Milk from different cows varies considerably from this average, however, the greatest difference being in the percentage of butter-fat, some cows giving milk low in fat and others high in fat. The parts of milk other than water are known as milk solids, or as total solids, and the solids other than butter-fat, as solids not fat. The milk minus the fat is known as the milk-serum, or as the milk-plasma. As shown by its composition, milk contains all the five food groups and is a balanced food product.



a b

FIG. 149. — A four-bottle hand power tester.

The fat of milk rises as cream. It is an emulsion of globules so small that a single drop contains more than a hundred million. Even from the same cow the globules are not all of the same size; some may be two or three times as large as others. The average size depends largely on the breed of cow.

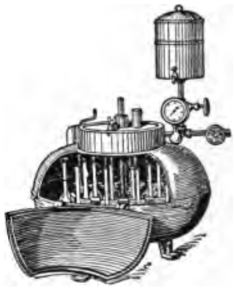


FIG. 150. — A type of steam tester with an arrangement for heating the water used in the test.

The protein is chiefly of two kinds, casein and albumin. Casein is the chief constituent of cheese. Albumin of milk is somewhat like the white of egg. When whey is heated to 160° F., the albumin coagulates.

Milk-sugar, the carbohydrate of milk, is less sweet than cane-sugar. It is used extensively for the modification of cow's milk for infants and is the most readily digested of all sugars.

The ash, or mineral matter of milk, consists chiefly of the chlorides and phosphates of sodium, potassium, magnesium, and calcium.

192. Testing of milk for fat. — It is important that the dairyman know the percentage of fat contained in the milk, for milk is often rated in value according to its fat-content. To measure the fat, use is made of a centrifuge known as a Babcock tester, which method was originated in 1890 by S. M. Babcock, Chief Chemist of the Wisconsin Experiment Station. The Babcock milk tester is used also to determine the percentage of fat in cream, skim-milk, buttermilk, and whey.

An outfit for making the test consists essentially of a centrifuge, a pipette, an acid measure, whole-milk bottles, cream-bottles, skim-milk bottles, cream scales, and dividers. A centrifuge is a horizontal wheel fitted with swinging cylindrical cups. A drawing of a small hand power four-bottle tester is shown in Fig. 149, *a*. The wheel is rotated by means of a gear that is turned in hand power machines by power applied at the handle. When the wheel is rotated the cups as-

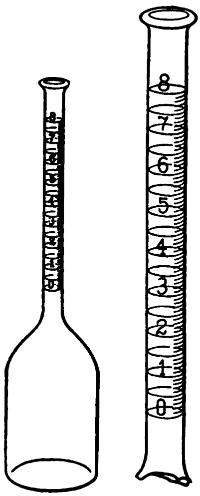


Fig. 151. — Type of Babcock test bottle conforming to the requirements of the United States Bureau of Standards, and showing graduations.

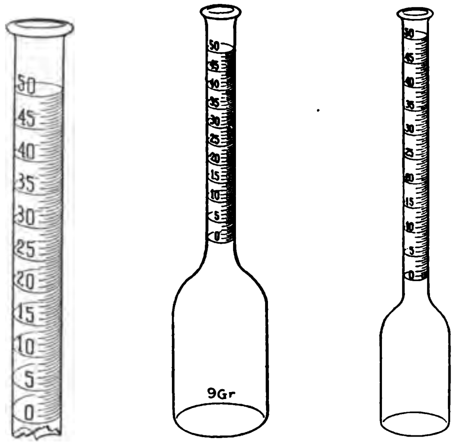


Fig. 152. — Types of cream bottles conforming to the requirements of the United States Bureau of Standards.

sume a horizontal position with the openings pointing toward the center of the wheel, as shown in Fig. 149, *b*. A steam-power tester is shown in Fig. 150.

The neck of a whole-milk bottle is graduated to read to .1 per cent (Fig. 151), that of a cream bottle to .5 per cent (Fig. 152), and that of a skim-milk bottle to .01 per cent. The skim-milk bottles are provided with a double neck, a large one through which the milk is poured into the bottle and a small one that is graduated for the reading of the percentages of fat.

FIG. 153.—Pipette holding 17.6 cubic centimeters, used in measuring milk in the Babcock test.

The pipette (Fig. 153) is used for measuring the milk to be tested. It holds 17.6 cubic centimeters (abbreviation c.c.) to a line etched on the glass in the neck. The quantity of milk required for a test is 17.5 c.c., but as about 1 c.c. will adhere to the sides, the pipette is made 1 c.c. over measure. The weight of milk required is 18 grams; 17.5 c.c. of normal milk is equivalent to 18 grams. The acid measure (Figs. 154 and 155) holds 17.5 c.c. of sulfuric acid, the quantity required for the test. In factories where many samples are tested, large acid bottles or burettes (Figs. 156 and 157), fitted with pinch cocks and arranged to measure a number of charges of 17.5 cc.. of acid are used; they are more convenient than the individual measures.

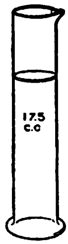


FIG. 154.—Simple acid graduate.

In testing cream, scales are used to weigh the quantity (18 grams) required (Fig. 158). Commercial sulfuric acid having a specific gravity of 1.82 to 1.83 is used in making the tests. If an acid with a specific gravity less than 1.82 is employed the milk particles are not properly burned and particles of curd are likely to appear in

the fat. An acid that has over 1.83 specific gravity has a tendency to char the fat and should not be used. The acid must be kept in glass bottles that are fitted with glass stoppers.

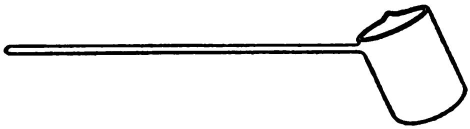


Fig. 155.—A dipper made entirely of glass and holding 17.5 cubic centimeters for measuring the acid.

In making a test, these directions should be followed: Mix thoroughly the sample to be tested, place the pipette in the milk, and suck milk into the tube until it is above the level of the etched line on the neck. Place the forefinger over the end of the pipette and the milk will remain in the tube. Remove the pressure of the finger slightly and allow the milk to run out of the end of the pipette until it is on a level with the etched line, thus leaving 17.6 c.c. of milk in the pipette. Place the end of the pipette in the neck of the test bottle and allow the milk to flow into the bottle. Fig. 159 shows the correct way to hold the bottle and the pipette. If they are both held in a vertical position the milk is almost sure to spill (Fig. 160). Next, fill the acid measure with acid (17.5 c.c.) and pour it into the test bottle. Slant the bottle as before. If the acid has been poured into the milk carefully, the two liquids will be in two layers in the bottle. Mix the acid and milk by gently rotating the bottle. Continue this rotating until all pieces of curd that form in the mixture are dissolved. Allow the mixture to stand a few minutes, then rotate the bottle again for a short time. Place the bottles in the tester in an upright position. The tester should be full of

Fig. 156.—Burette for measuring the acid.

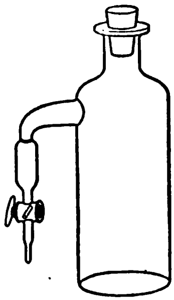


Fig. 157.—A combined bottle and acid measure.

bottles. If there are not enough samples, fill the unused cups with test bottles of water. Turn the handle of the tester for four minutes at the speed indicated for the machine in use. Add moderately hot water to the bottle to bring the fat up to the neck of the bottle. A pipette is convenient for this. Clean, soft water should be used. If the water available contains much lime, add to it a few drops of sulfuric acid to neutralize the lime. After the water is added, put the bottles back in the machine and whirl them again for one minute. Add hot water as before until the fat stands at about the 7 per cent mark in the neck of the bottle. Place the bottles in the machine again, whirl for one minute, and read the percentage of fat, as shown in Fig. 161. The temperature of the sample when read should be about 140° F. To calculate the reading, subtract the reading at *a* (Fig. 161) from that at *b*. A convenient way to determine the reading is to place the points of a pair of dividers at the top and the bottom of the fat-column (see Fig. 162); then, being careful to keep this same distance between the points, slide them down until the lower one is at the zero mark, as shown by the dotted lines. The upper one will give the reading direct.

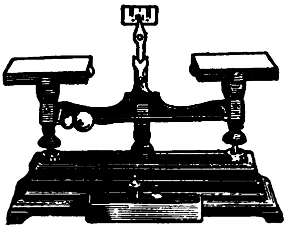


FIG. 158. — Type of knife-edge cream balance.

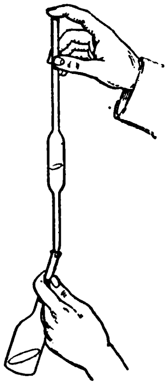


FIG. 159. — The right way of adding milk to the test bottle. (Farrington and Wall, *Testing Milk and Its Products.*)

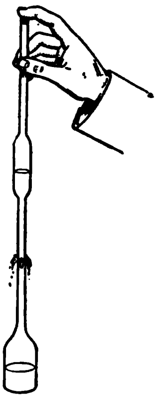


FIG. 160. — The wrong way of adding the milk to the test bottle. (Farrington and Wall, *Testing Milk and Its Products.*)

The methods of testing cream, skim-milk, buttermilk, and

whey differ in a few details from that of testing whole milk. When testing cream, the sample is weighed, 18 grams being the quantity used. About 17.5 c.c. of acid is added to each sample, but the quantity is varied slightly with the richness of the cream, rich cream requiring slightly less acid than thinner cream. Experience will aid in determining the exact quantity to be used. Be careful when rotating the bottles after adding the acid; the fat will burn if the rotating is too vigorous. After the acid is added let the sample stand four minutes before placing it in the tester. The other operations are the same as for whole milk. In reading the percentage of fat, read as shown in Fig. 163. When testing skim-milk, buttermilk, or whey, use 20 c.c. of acid. Place each bottle in the tester with the filling tube toward the center. This is to prevent any fat from being caught between the tube and the sides of the bottles after the whirling in the tester. Turn the tester a little faster than for whole milk. If there is a layer of curd at the bottom of the fat column do not include it in the reading. Read the fat column as for whole milk. A pair of dividers is especially useful for these readings.

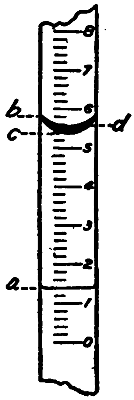


FIG. 161.—Method of reading fat column in milk testing. Read from *a* to *b*, not from *a* to *c*, nor *a* to *d*.

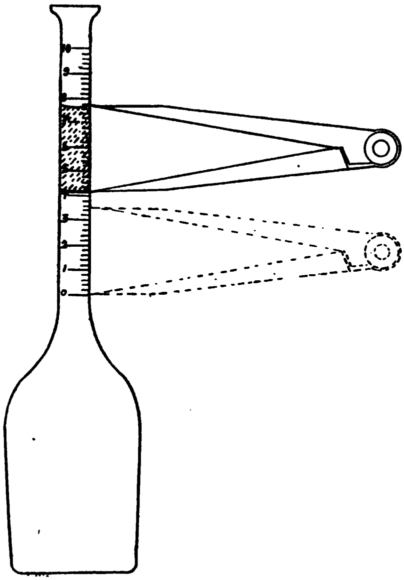


FIG. 162.—Dividers for measuring length of fat column.

193. Separation of cream from milk. — The best way to separate cream from whole milk is to use a centrifugal cream separator. The saving of butter-fat by the use of one of these machines soon pays for its cost and upkeep. By adjustment of the screw on the separator, cream of any desired richness, up to a certain limit, can be produced. The milk passes into a bowl on the machine and the bowl is revolved at a high rate of speed. By reason of centrifugal force, the heavier part of the milk — the skim-milk — is thrown toward the outside and the lighter part — the fat with some milk — is crowded toward the center of the bowl. Near the side of the bowl at the top is an opening through which the skim-milk passes and near the center of the bowl, one through which the cream passes. The skim-milk and the cream are carried from the separator through spouts and into pails or cans placed near the machine.

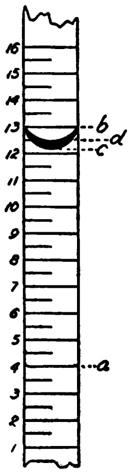


Fig. 163. — Method of reading fat column in cream testing. Read from *a* to *c*, not *a* to *b*, nor from *a* to *d*.

194. Bacteria in milk. — Most of the fermentations that occur in milk are due to bacteria. Not all bacteria are harmful, in fact many are useful, but milk containing large numbers should be looked on with suspicion, as many undesirable bacteria are likely to be present with the beneficial ones. Bacteria reproduce very rapidly at high temperatures and more slowly at low temperatures. At 70° F., the growth is rapid, at 50° F., it is retarded, and at 40° F., it is very slow. Thus in milk not properly cooled, the bacteria multiply very rapidly. This is shown graphically in Fig. 164. One of the most numerous kinds of bacteria in milk causes lactic acid to form. The bacteria break down the milk-sugar and produce lactic acid or, in other words, cause the milk to become sour. There are several types of lactic-acid bacteria; those that grow under 70° F. are useful, especially in the manufacture of butter and

cheese. The rich flavor of these products is due largely to these bacteria. If milk sours at a high temperature, an undesirable type is likely to grow. These produce gas as well as lactic acid and are responsible for so-called gassy curd when the milk is made into cheese. Those of another type destroy the casein and albumin of the milk and cause putrefaction and bad odors. This type is, of course, undesirable.

Disease germs are often carried in the milk, especially those causing typhoid fever, tuberculosis, diphtheria, and scarlet fever. Milk may become contaminated by bacteria from the udder itself, but this contamination is usually harmless unless the udder is affected with tuberculosis, garget, or some form of inflammation. The greatest number of bacteria in milk come from the dust of the air, the dirt and manure on the udder and flanks of the cow, from the clothes of the milker, and from unclean utensils. Cleanliness about a stable and dairy-house is, therefore, a very important means of reducing the number of bacteria in milk.

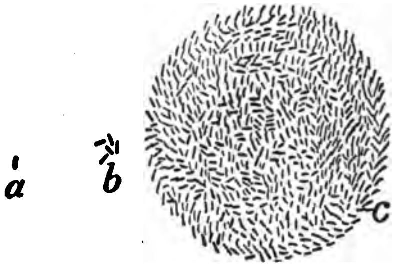


Fig. 164. — This diagram shows the rapidity with which bacteria multiply in milk not properly cooled. A single bacterium (*a*) in 24 hours multiplied to 5 (*b*) in milk kept at 50° F.; (*c*) represents the number that developed from a single bacterium kept 24 hours at 70° F.

195. Production of sanitary milk. — Healthy cows are most essential to the production of sanitary milk. Milk from diseased cows is likely to contain disease-producing bacteria. At least once a year the cows should be tested for tuberculosis by a competent veterinarian and all animals that show reaction should be removed from the herd. All cows added to the herd should be tuberculin-tested. If at any time the cows give slimy, ropy, watery, or otherwise abnormal milk, it should not be used.

Keeping foreign matter out of the milk. — Dust, hair, and manure should, by all means, be kept out of the milk. To do this certain precautions must be taken. The cows must be groomed and the hair clipped from the udders, flanks, and tails. They must not be fed, bedded, or groomed immediately before milking, as these operations fill the stable with dust and bacteria. The stalls must be kept clean and manure and soiled bedding removed from the stall frequently. The stable must be kept in a sanitary condition.

Kind of utensils for milk. — All utensils that come in contact with the milk should be of durable, smooth, non-absorbent material. Sterilization of these utensils is important. All seams in cans or pails should be flushed with solder. Rusty or battered utensils should never be used, because it is impossible to clean impurities from the rough surfaces. It is necessary, when washing the vessels, to rinse them first in cold or lukewarm water to remove the milk, then in hot water that contains an alkali like sal soda, followed by a thorough rinsing in clean hot water, after which they should be set aside to dry. A brush for washing the utensils is more sanitary than a cloth.

Fig. 165. — Clean white suits and small-top milk pails used in a sanitary dairy.

Care during the milking. — Considerable care is necessary

during the process of milking. Before starting to milk, the udder, flanks, and bellies should be carefully wiped with a clean damp cloth to remove any loose hairs or dust that might fall into the pail. Following this, the milker should put on clean overalls (Fig. 165) and wash his hands. Small-topped pails should be used, experiments showing that milking in such pails safeguards the milk and reduces the number of bacteria. A pail like the one shown in Fig. 166 may be secured by soldering a hood on an ordinary pail.

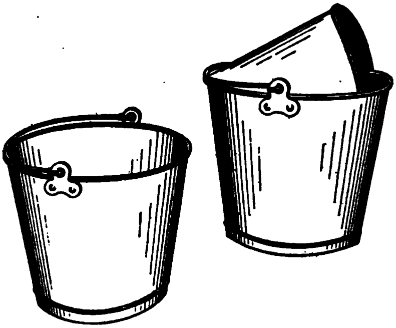


FIG. 166. — Open and small-top milk pails.

The milking should be done with dry hands. The practice of milking with wet hands is an undesirable habit, not only because of the drops of water that fall into the milk, but because of the possibility of causing chapped teats. Before milking each cow, the milker should wash his hands.

Care of milk in the milk-house. — After each cow's milk is drawn it should be carried at once to the milk-house, weighed, recorded, sampled for the composite test, if one is to be made, strained, and cooled. The milk after being cooled should be bottled at once and placed in a cold room, or it should be put in cans and placed in a tank of cold water. The dairy-house should be so constructed as to fulfill sanitary requirements and still be practical and inexpensive.

196. Pasteurization of milk. — Whenever there is any doubt about the purity of raw milk, it should be pasteurized. This can be done by heating to a temperature somewhat less than boiling (145° F. is proper), retaining this temperature for a time, then cooling it immediately. Heating the milk to 145° F. and holding it at this temperature for twenty minutes will usually

be sufficient to pasteurize it. Bacteria that cause tuberculosis and other harmful bodies are killed by pasteurization. Not all of the lactic-acid bacteria are killed, however, and the milk will sour, but not so quickly as dirty raw milk. Pasteurized milk should be consumed within about twenty-four hours after it has been heated, since a long time before it sours it is likely to become dangerous as human food. This is because in raw milk, certain putrefactive bacteria are kept from growing by the acidity of the milk, but in pasteurized milk, since it does not sour quickly, these bacteria are likely to become active and, if the milk is old, cause it to become impure or even dangerous for use.

QUESTIONS

1. Why should the producer of milk know the percentage of fat it contains?
2. How is milk tested for fat?
3. State the advantages of the centrifugal cream separator.
4. What causes milk to ferment?
5. Why should milk be cooled soon after milking?
6. State some beneficial effects of bacteria in milk; some harmful ones.
7. What precautions should be taken to exclude disease-producing bacteria from milk?
8. Describe briefly how sanitary milk can be produced.
9. Why should flies be kept out of the dairy?
10. How is milk pasteurized? Why should pasteurized milk be used within about twenty-four hours after pasteurization?

EXERCISES

1. **Separating cream from milk.** — Secure a centrifugal separator and about five gallons of fresh whole milk. Take the separator apart and put it together again, studying its construction. Notice the cream screw. When a rich cream is desired the screw is turned toward the center of the bowl, when a thin cream is wanted it is turned in the opposite direction. Read carefully the directions furnished by the manufacturer about operating the cream screw. Warm the milk until it is about 85° F. and run it through the separator. Milk separates best

at about this temperature. Take samples of the cream and the skim-milk and save them for testing. Mix the milk and cream that have been separated, heat to 85° F., change the adjustment of the cream screw, and run the milk through the machine again. Take samples as before for testing. Change the adjustment of the cream screw, mix the milk and cream, and separate again. Under favorable conditions a separator should not leave more than .1 per cent of cream in the skim-milk and .05 per cent is what operators should try to secure.

2. **Testing for butter-fat.** — Test for butter-fat the samples of milk and cream secured in the previous exercise. Follow carefully the directions as given in the chapter. If there is not a Babcock testing outfit among the school equipment, it will usually be possible to borrow one from some one in the neighborhood. If this cannot be done, a creamery or skimming station should be visited at a time when the cream is being tested and the process observed closely. Small testing outfits can be purchased cheaply from creamery supply houses, dealers in agricultural laboratory supplies, and catalog houses.

3. **Impurities in milk.** — To test the quantity of impurities in milk, secure several quarts from different sources, a roll of absorbent cotton, a small piece of wire screen, several empty quart bottles, a dairy thermometer, and a sauce pan. Place the wire screen over the mouth of one of the empty quart milk bottles, spread a layer of absorbent cotton over the screen, heat one of the quarts of milk to a temperature of about 100° F. and pour it through the absorbent cotton into the bottle. Remove the cotton and mark it to designate the source of milk that was poured through it. Follow same instructions with other quarts of milk. Examine the pieces of cotton. Unclean milk will leave a stain on the cotton, and the dirtier the milk, the darker will be the stain. Add varying quantities of dust to the different lots of milk, repeat the experiment, and observe the results. Many creameries and cheese factories make sediment tests of the milk of their patrons. If such tests are made at local factories, ask to see the disks from different patrons.

4. **Cleanliness of dairy utensils.** — The equipment required for this exercise is two pint jars with covers, a quart of fresh milk, a tooth pick, and a dairy utensil that has unflushed seams. Fill the pint jars with milk, scrape material from the seams of the utensil with the tooth pick, and put this dirt in one of the jars, but not in the other. If no utensil with unflushed seams is available, place some milk in a tin can or cup that has unflushed seams, allow the milk to sour, pour it out, then scrape the seams. Place the covers loosely over both jars and set them away about five or six hours where the temperature is anywhere from 70 to 90° F. At the end of the time notice carefully the odor and

taste of the milk in the two jars. Examine the milk pails and cans at local hardware stores. Are they made with flushed seams?

5. **Absorption of odors by milk.** — For this exercise you will require a banana, three quarts of milk, two shallow pans, two empty quart milk bottles, a tight box in which the pan can be placed, and a cover for the box. The first part of the exercise is conducted in the school laboratory. A banana is used as the source of the odor. Pour a quart of milk into one of the pans and place the pan in the box. Remove the skin from the banana and lay the fruit in the box near the pan of milk. Place the cover on the box and keep it closed for twenty-four hours. At the end of the time open the box and examine the milk for odor.

The second part of the exercise is conducted on some dairy farm in the neighborhood. Visit the farm during milking time and as soon as a cow has been milked pour a quart of milk in the shallow pan and fill the quart bottles with milk from the same source. Leave the pan uncovered in a stable for several hours. Remove the quart bottle from the stable at once, aërate the milk by pouring it several times from one bottle to another, place a cap on the bottle, and set it away in a cold place for ten to twelve hours. At the end of the time have the two lots of milk brought to the school-house and examine them for odor. The way to avoid the odor of the stable in milk is to keep the stable clean and to remove the milk to another building soon after the milking of the cows. Where would you be most likely to get a cowy odor in milk, in a clean, well ventilated stable, or in a dirty, poorly ventilated stable? Why should milk be aërated?

6. **Scoring dairy farms.** — The score-card given herewith is the one published by the Dairy Division of the United States Department of Agriculture. Using this score-card visit several dairy farms and score the dairies. Those that score above 80 per cent are producing high grade milk, those from 70 to 80 per cent are producing reasonably clean milk, and those that are 50 per cent or below are producing dirty milk. On your inspection trip you will undoubtedly find dirty dairies as well as clean ones.

Score-card for Dairy Farm

Equipment	Score: Perfect	Score: Allowed
COWS		
Health	6	......
Apparently in good health 1		
If tested with tuberculin within a year and no tuberculosis is found, or if tested within six months and all reacting animals removed . . 5		
(If tested within a year and reacting animals are found and removed, 3.)		
Food (clean and wholesome)	1	......
Water (clean and fresh)	1	......
STABLES		
Location of stable	2	......
Well drained 1		
Free from contaminating surroundings . . . 1		
Construction of stable	4	......
Tight, sound floor and proper gutter . . . 2		
Smooth, tight walls and ceiling 1		
Proper stall, tie, and manger 1		
Provision for light: Four sq. ft. of glass per cow	4	......
(Three sq. ft., 3; 2 sq. ft., 2; 1 sq. ft., 1. Deduct for uneven distribution.)		
Bedding	1	......
Ventilation	7	......
Provision for fresh air, controllable flue system 3		
(Windows hinged at bottom, 1.5; sliding windows, 1; other openings, 0.5.)		
Cubic feet of space per cow, 500 ft. 3		
(Less than 500 ft., 2; less than 400 ft., 1; less than 300 ft., 0.)		
Provision for controlling temperature 1		
UTENSILS		
Construction and condition of utensils	1	......
Water for cleaning	1	......
(Clean, convenient, and abundant.)		
Small-top milking pail	5	......
Milk cooler	1	......
Clean milking suits	1	......

Methods	Score: Perfect	Score: Allowed
COWS		
Clean	8	......
(Free from visible dirt, 6.)		
STABLES		
Cleanliness of stables	6	......
Floor 2		
Walls 1		
Ceiling and ledges . . 1		
Mangers and partitions . 1		
Windows 1		
Stable air at milking time	5	......
Freedom from dust . . 3		
Freedom from odors . . 2		
Cleanliness of bedding	1	......
Barnyard	2	......
Clean 1		
Well drained 1		
Removal of manure daily to 50 feet from stable	2	......
MILK ROOM OR MILK HOUSE		
Cleanliness of milk room	3	......
UTENSILS AND MILKING		
Care and cleanliness of utensils	8	......
Thoroughly washed . . . 2		......
Sterilized in steam for 15 minutes 3		
(Placed over steam jet, or scalded with boiling water, 2.)		
Protected from contamination 3		
Cleanliness of milking	9	......
Clean, dry hands . . . 3		
Udders washed and wiped 6		
(Udders cleaned with moist cloth, 4; cleaned with dry cloth or brush at least 15 minutes before milking, 1.)		
HANDLING THE MILK		
Cleanliness of attendants in milk room	2	......
Milk removed immediately from stable without pouring from pail	2	......
Cooled immediately after milking each cow	2	......
Cooled below 50° F.	5	......
(51° to 55°, 4; 56° to 60°, 2.)		
Stored below 50° F.	3	......

SCORE-CARD FOR DAIRY FARM (*Continued*)

Equipment	Score Perfect	Score Allowed	Methods	Score Perfect	Score Allowed
MILK ROOM OR MILK HOUSE			HANDLING THE MILK — *Cont.*		
Location: Free from contaminating surroundings	1	......	(51° to 55°, 2; 56° to 60°, 1.)		
Construction of milk room	2	......	Transportation below 50° F.		......
Floor, walls, and ceiling . 1			(51° to 55°, 1.5; 56° to 60°, 1.)		
Light, ventilation, screens 1			(If delivered twice a day, allow perfect score for storage and transportation.)		
Separate rooms for washing utensils and handling milk	1	......			
Facilities for steam . . . (Hot water, 0.5.)	1	......			
Total	40	......	Total	60	......

Equipment.................. + Methods............... = ...Final Score.

NOTE 1. — If any exceptionally filthy condition is found, particularly dirty utensils, the total score may be further limited.

NOTE 2. — If the water is exposed to dangerous contamination, or there is evidence of the presence of a dangerous disease in animals or attendants, the score shall be 0.

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CHAPTER XIX

SHEEP

Classes of sheep.
Middle-wool breeds.
    Southdown, Shropshire, Hampshire, Oxford, Dorset, Cheviot.
Long-wool breeds.
    Leicester, Cotswold, Lincoln.
Fine-wool breeds.
    American Merino, Rambouillet.
Feeds for sheep.
Importance of shepherd dogs.
Sheep-killing dogs.
Catching, holding, and leading sheep.

When rightly managed sheep give good returns on the investment, they furnish a valuable food product, and wool that can be manufactured into the warmest of cloth. With all these good qualities, however, not many sheep, compared with the other classes of live-stock, are found on American farms. Sheep are abundant in the western country, but on the farms of the Central States, the East, and the South many more might be raised, although the profit-and-loss elements of the industry must determine the extent to which it can be carried. The cur-dog nuisance is partly responsible for lack of sheep, but another reason is that farmers as a whole know little about sheep raising. Many of them think the management of a flock a difficult task, but experience shows that this is not true. Sheep are really not more difficult to manage than other classes of live-stock. However, merely because sheep thrive in a given region does not prove that they should be raised there; other kinds of farming may be more profitable.

197. Classes of sheep. — Of the thirty breeds of improved sheep, eleven are fairly well established in the United States. These may be grouped into three classes known as middle-wool, long-wool, and fine-wool classes. The points of a sheep from the side, front, and rear views are shown in Figs. 167 and 168.

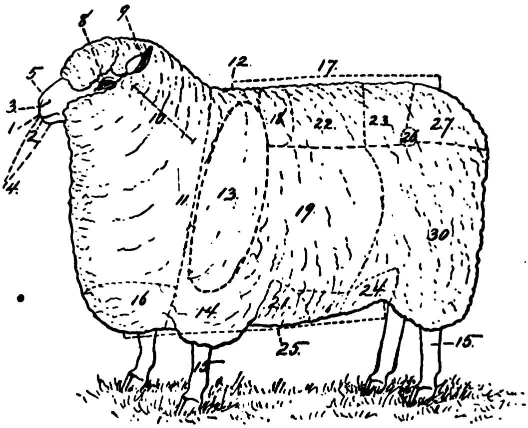

FIG. 167. — Points of the sheep, side view. 1, muzzle; 2, mouth; 3, nostril; 4, lips; 5, nose; 8, eye; 9, ear; 10, neck; 11, neck vien, or shoulder; 12, top of shoulder; 13, shoulder; 14, arm; 15, shanks; 16, brisket, or breast; 17, top line; 18, crops; 19, ribs; 21, fore flank; 22, back; 23, loin; 24, hind flank; 25, underline; 26, hip; 27, rump; 30, thigh, or leg of mutton.

198. Middle-wool breeds. — The breeds of the middle-wool class are Southdown, Shropshire, Hampshire, Oxford, Dorset, and Cheviot. The first four are known as the down breeds, a name applied by reason of the hilly, or as it is termed, downs country of England where they originated. The down breeds and the other two of this class are bred primarily for mutton and secondarily for wool-production. The wool, although it is of medium length, brings considerable return to the owners of the flocks and is an important item.

Southdown. — The oldest of the middle-wool breeds is the Southdown. The animals are very uniform in appearance, as may be seen in Fig. 169. They are extremely blocky, low-set,

compact with good width of back, thickness of loin, and plumpness of thighs. In mutton form they excel all the other breeds. The head is short and broad, wide between the eyes, the ears are short, small, and pointed and are covered on the outside with tufts of wool. The face below the eyes is covered with brownish-gray hair, and the cheeks and forehead with wool. The legs, like the face, are covered with hair. The animals are the smallest of the mutton breeds, rams weighing about one hundred seventy-five pounds and ewes about one hundred

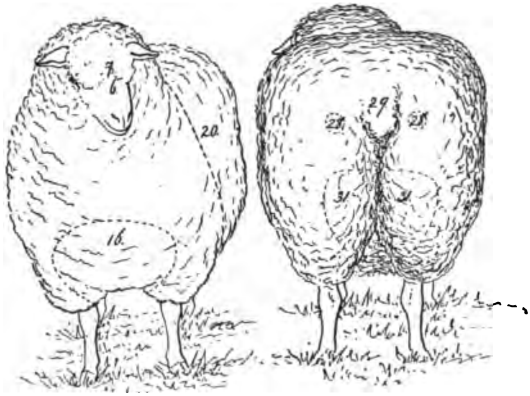

FIG. 168.—Points of the sheep, front and rear views. 6, face; 7, forehead; 16, brisket, or breast; 20, girth, or heart girth; 28, pin bones; 29, dock, or tail; 31, twist.

thirty-five pounds. As a breed they are active and adapted to hilly pastures. The fleece is very dense and short.

Shropshire. — The most widely known breed of sheep in America is the Shropshire (Fig. 170). The animals are low-set, broad, deep, and well fleshed, but they do not have as good mutton form as the Southdowns. The head is wooled over, except the nose, which is covered with brown hair. The ears are slightly pointed and are covered on the outside with tufts of fine wool. The legs, where not wooled, are covered with hair the same color as that on the nose. In size the

Fig. 169. — Southdown sheep on a government farm in Vermont.

animals are intermediate between the Southdown and the Oxford. The rams usually weigh about two hundred twenty-five pounds and the ewes from one hundred fifty to one hundred sixty pounds. In weight and length of fleece the Shropshire ranks among the best of the middle-wool breeds and the wool is evenly distributed over the body, often extending down to the hoofs.

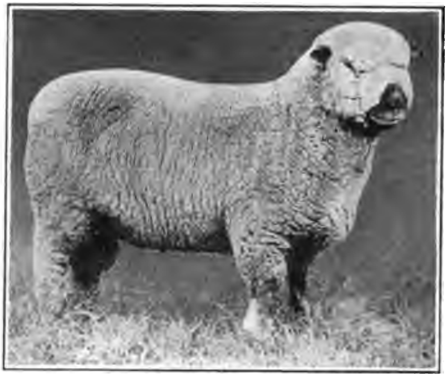

FIG. 170. — Shropshire ram.

Hampshire. — The breed noted especially for the rapid and early growth of the lambs is the Hampshire (Fig. 171). The animals are of the general mutton form, but are tall, big-boned, rugged, and inclined to be somewhat coarse in appearance. The head is large, is wooled only on the forehead and cheeks; the remaining parts are covered with black hair. The nose is Roman, which is a distinguishing feature. The ears are large, carried straight out from the head, and covered with black hair the same as on the face. The animals are large; rams weigh about two hundred fifty pounds and ewes from one hundred eighty-five to one hundred ninety-five pounds. The fleece is not so good as in most of the

FIG. 171. — Hampshire ewe.

middle-wool breeds; it is usually short, rather thin, and not well distributed over the body.

Oxford. — Formed by crossing Hampshires and Cotswolds, a long-wool sheep, the Oxford has become one of the important breeds. The animals are the largest of the middle-wool breeds, rams weighing from two hundred fifty to three hundred fifty pounds and ewes from one hundred eighty to two hundred seventy-five pounds. These sheep are especially well developed in back, loin, and hindquarters. In appearance of head they somewhat resemble the Shropshire, although the head is longer and is wooled only down to the eyes. The remainder of the face is covered with light-brown hair. The ears are longer than those of the Shropshire and are covered with hair. The legs are covered with hair, also. The fleece is long and coarse, averaging about 10 per cent heavier than that of the Shropshire. It is usually somewhat open, but is close enough for the protection of the animals.

FIG. 172. — Dorset ewes.

Dorset. — A distinguishing feature of the Dorset breed (Fig. 172) is that both ewes and rams have horns. The form of the animal is similar to that of the Shropshire, but is somewhat less symmetrical. The ears, legs, and face, except a foretop of wool, are covered with fine white hair. The skin of the nose is usually pink. In size the animals are medium, the rams weighing about two hundred pounds and the ewes one hundred sixty pounds. The fleece is medium in coarseness and length; it often lacks density and is not evenly distributed,

the under side of the body frequently being short-wooled, or bare. Strong features of the Dorset are the breeding habit, the prolificacy, and the milking quality of the ewes. The ewes can be bred to lamb in the fall; this makes the breed popular with farmers who desire to grow "hot-house lambs," that is, lambs that can be marketed from Thanksgiving to Easter. The ewes can be bred to lamb twice a year, but this practice is not advised. Twin lambs are rather common, more so than with other breeds. The milking qualities of the ewes is above the average and, largely on this account, the lambs grow rapidly and come to marketable age early.

Cheviot. — Animals of the Cheviot breed (Fig. 173) have been raised for centuries in the Cheviot Hills near the border of Scotland and England. They are vigorous, alert, and hardy and can often be raised on high rugged lands that are unsuited to the other breeds. The form approaches the mutton type, but it does not equal that of the down breeds. The head, face, and ears are characteristic in appearance, the head being broad between the eyes, the ears erect, and the face and ears covered with fine, white hair. The fleece ends just back of the ears and about the throat in a ruff. The legs are clean of wool and are covered with hair like that on the face and ears. In size the animals are medium, rams weighing about two hundred pounds and ewes about one hundred fifty pounds. The wool is of excellent quality, rather light in weight, and is white in contrast to the gray tinge of the down breeds.

Fig. 173. — Cheviot ram.

199. Long-wool breeds. — The breeds of long-wool sheep are Leicester, Cotswold, and Lincoln. The animals are raised chiefly for mutton. They are the largest sheep grown and are large-framed and square-bodied with broad backs. The fleeces are more open, coarser, and longer than those of the other classes. On account of their size they are best suited for level lands where feed can be obtained without much travel. They stand wet weather well, the long wool shedding water better than that of the middle-wool breeds. The lambs do not mature so rapidly nor fatten so young as those of middle-wool animals.

FIG. 174. — Leicester ewe.

Leicester. — The first breed of sheep to be improved by careful selection and breeding was the Leicester (Fig. 174). Robert Bakewell, one of the early and foremost breeders of live-stock in England, used these animals in his work. Leicesters have a characteristic appearance of head and face; the head is bare of wool from the ears forward and the face is lean and tapers toward the muzzle with a slightly Roman nose and is covered with short, white hair with an occasional black spot. The ears and legs, like the face, are covered with hair. The form is square, the back wide and well covered with flesh, and the rump prominent. The animals are the smallest of the long-wool breeds, the rams weighing from two hundred twenty-five to two hundred fifty pounds and the ewes from one hundred seventy-five to two hundred pounds. The fleece is long, white, and fine, and hangs in locks that are smaller than those of the other long-wool breeds.

Cotswold. — The native home of these sheep (Fig. 175) is

the Cotswold Hills of England. The animals are somewhat upstanding, but are of good mutton form and possess strong, well fleshed backs and loins. The face and ears are covered with white or grayish hairs and the head carries a heavy fore-lock of wool that falls over the face and eyes, as shown in Fig. 175. The animals are among the largest of sheep, ranging from two hundred to two hundred fifty pounds. The wool hangs in long wavy ringlets all over the body, except the face, and yields a large quantity of fleece.

FIG. 175. — Cotswold ram.

Lincoln. — The native home of the Lincoln breed (Fig. 176) is England, where conditions are well adapted for the development of large sheep. The animals are shorter and more compactly built than the Cotswold and show a massive, square mutton frame. The face, ears, and legs below the knees and hocks are covered with white hair. On the head is a tuft of wool. The animals average in weight from two hundred to two hundred fifty pounds and they shear a very heavy fleece.

200. Fine-wool breeds. — The breeds of the fine-wool class are American Merino and Rambouillet. All these fine-wool sheep are descendants from Spanish stock. The animals have been bred principally for the production of wool, although in the C type of Merino (see the next paragraph) and the Ram-

FIG. 176. — Lincoln ewe.

bouillet the breeders have improved the mutton qualities and have kept the fine-wool characteristic.

American Merino. — The American Merinos are the smallest of all breeds, the rams ranging from one hundred to one hundred seventy-five pounds and the ewes from eighty to one hundred pounds. The head is small and covered with wool, except the tip of the nose. The males have heavy, incurving, spiral horns; the females are hornless. The fleece is from two to two and one-half inches in length and is very dense and fine. The whole body is covered with wool and the area of the wooled surface is increased by the presence of wrinkles and folds. The Merinos are grouped into three classes, A, B, and C, according to the presence or absence of the wrinkles and folds. Animals of class A (Fig. 177) have heavy wrinkles and folds; those of class B have few wrinkles about the neck and brisket and in some cases on the thighs; those of class C are still less wrinkled, often having only a slight suggestion of wrinkles about the neck. They are often known as Delaine Merinos

FIG. 177. — Type A, Merino ram.

and are somewhat larger than those of the other two classes, and have slightly longer and coarser wool and more of the mutton form. Some authorities make the Delaine Merinos a separate breed.

Rambouillet. — The animals of the Rambouillet breed (Fig. 178) are larger than those of the other fine-wool sheep, the rams weighing from one hundred seventy-five to one hundred eighty pounds and the ewes from one hundred forty to one hundred eighty pounds. Although the sheep are rather upstanding, the form approaches that of the mutton type and the animals produce a good quality of mutton as well as fine wool. The head is larger than in the Merinos and is wooled well down on the nose. The wool is about three inches long and the fleece completely covers the body.

FIG. 178. — Rambouillet ewe.

201. Feeds for sheep. — Sheep are capable of digesting large quantities of roughage, but they should have concentrates in addition. Excellent roughages for sheep are the leguminous hays from alfalfa, red clover, alsike clover, or cowpeas. Corn stover, straws, and hays from some of the grasses are often fed to sheep, but they are inferior to the leguminous hays. Timothy or millet hays should not be fed to sheep. The former causes constipation and the latter, scours.

Pasturage is the important feed for sheep. They are naturally grazing animals and, like all animals that chew their cud, require abundant succulent feed. Permanent pastures of

blue-grass, white clover, Bermuda-grass, meadow-fescue, or red clover, usually in mixtures, make good sheep pasture. A number of annual crops also are used for sheep pasture. Among these are rape, oats and peas, vetches, cowpeas, soybeans, barley, kale, and wheat.

Roots are often fed to sheep in winter to supply succulent feed. They should be pulped or cut into small pieces. Turnips and rutabagas are best; sugar-beets and mangels are not usually satisfactory. Silage is a useful succulent for sheep. If it is of good quality, it can be fed with satisfactory results, but if sour, moldy, or frozen, it should never be utilized. Cabbage is used for sheep, especially show sheep. The animals relish it, but for commercial feeding cabbage is too expensive and, moreover, does not keep well in storage. Pumpkins, if cut into small pieces, can be fed to sheep very satisfactorily. They are especially useful in adding variety to the ration.

Among the concentrates for sheep are corn, barley, oats, peas, whole cottonseed, cottonseed meal and cottonseed hulls mixed, linseed meal, gluten feed, and bran.

202. Importance of shepherd dogs. — A well trained shepherd dog is a valuable asset to any farmer who raises sheep. A dog can be taught to herd the flock and will watch them tirelessly and warn the owner of any prowler that may be near. Scotch collies are the sheep dogs used in America and for this purpose are invaluable.

203. Sheep-killing dogs. — In contrast to the well trained dog is the cur sheep-killing dog. Dogs of this class have prevented many farmers from raising sheep and have caused others to sell their flocks. Thousands of sheep have been killed or injured by such dogs, and whenever a flock becomes ravaged, the sheep are restless and easily excited and not likely to make normal gains in weight for two weeks afterwards; this loss must be added to that of the sheep killed or injured. In some cases flocks have become so restless that they had to be sold.

Among the remedies for the cur-dog nuisance are stringent

dog-laws, dog-proof wire fences, sheep-bells, and the keeping of more sheep. Stringent dog-laws rigidly enforced will aid much toward the solution of the problem. In England, where such laws are in force, skeep-killing by dogs is much less common than in America. A yard inclosed by a dog-proof fence into which the sheep are driven at night is an effective aid in protecting the animals. Sheep-bells serve as a warning where the flock is disturbed and thus it is a good plan to have several in each flock. The raising of more sheep in any community, especially in one in which not many farmers have sheep, will aid in solving the cur-dog problem, because the farmers will then be more active in promoting dog laws.

204. Catching, holding, and leading of sheep. — Unless one is accustomed to handling sheep, one is likely to have difficulty in catching, holding, and leading them. A practical method of handling sheep when scoring, judging, or otherwise examining them is as follows: Step up quietly behind the sheep and grasp its hind leg just above the hock with the right hand. Sheep do not struggle much when caught by the leg in this manner. Never jump on the back of a sheep and try to hold it by the wool, as one is almost sure to frighten the animal and to loosen or pull out wool. Sheep to be scored or judged should be held by the head. To change position, when holding the sheep by the hind leg, step back and a little to the left of the animal, reach forward with the left hand and pass it under the neck from the left side, release hold of the hind leg, step forward, and place the right hand on the top of the neck, slide the left hand under the jaw, then pass the right hand over the forehead. With the hands in this position one can usually hold the sheep quietly, even if it is a rather stubborn animal, and if it is a quiet one, it can be held with one hand placed under the jaw.

A sheep is a stubborn animal to lead. To make it go forward, assume the position described above, leave one hand under the jaw, step back and grasp the root of the tail or the dock with the other hand and squeeze it. The sheep will

generally go forward when this is done, but if dragged by the head it is almost sure to pull back.

QUESTIONS

1. Name the three classes of sheep and give the general characteristics of each.
2. Which breed of sheep shows the best mutton form?
3. Describe and contrast Shropshire and Oxford sheep.
4. Which breed is used for the production of hot-house lambs?
5. Point out the general differences between the Leicester and Cotswold breeds.
6. Which of the breeds of the fine-wool class has been most developed as a dual-purpose breed?
7. Make a list of good roughages for sheep.
8. Why is silage a good feed for sheep?
9. Contrast the heads of the three long-wool breeds.
10. What remedies can you suggest for sheep-killing dogs?

EXERCISES

1. **Scoring and judging sheep.** — Making use of the score-card given herewith, score and judge sheep as directed for this work with the other classes of live-stock.

SCORE-CARD FOR FAT MUTTON SHEEP[1]

Scale of Points	Standard	Points Deficient: Student's Score	Points Deficient: Corrected
1. Age		. . . . .	. . . . .
General appearance — 38 per cent:			
2. Weight, score according to age	8	. . . . .	. . . . .
3. Form, long, level, deep, broad, low-set, stylish	10	. . . . .	. . . . .
4. Quality, clean bone; silky hair; fine pink skin; light in offal, yielding high percentage of meat	10	. . . . .	. . . . .
5. Condition, deep even covering of firm flesh, especially in regions of valuable cuts. Points indicating ripeness are, thick dock, back thickly covered with flesh, thick neck, full purse, full flank, plump breast . . .	10	. . . . .	. . . . .

[1] From Purdue University Circular 29.

SCORE-CARD FOR FAT MUTTON SHEEP (*Continued*)

SCALE OF POINTS	STANDARD	POINTS DEFICIENT: Student's Score	POINTS DEFICIENT: Corrected
Head and neck — 7 per cent:			
6. Muzzle, fine; mouth large; lips thin; nostrils large and open	1	.....	.....
7. Eyes, large, clear, placid	1	.....	.....
8. Face, short; features clean-cut	1	.....	.....
9. Forehead, broad, full	1	.....	.....
10. Ears, fine, alert	1	.....	.....
11. Neck, thick, short, free from folds	2	.....	.....
Forequarters — 7 per cent:			
12. Shoulders, covered with flesh, compact on top, snug	5	.....	.....
13. Brisket, neat, proportionate; breast wide	1	.....	.....
14. Legs, straight, short, wide apart, strong; forearm full; shank smooth, fine	1	.....	.....
Body — 20 per cent:			
15. Chest, wide, deep, full	4	.....	.....
16. Ribs, well sprung, long, close	4	.....	.....
17. Back, broad, straight, long, thickly fleshed	6	.....	.....
18. Loin, thick, broad, long	6	.....	.....
Hindquarters — 16 per cent:			
19. Hips, far apart, level, smooth	2	.....	.....
20. Rump, long, level, wide to tail-head	4	.....	.....
21. Thighs, full, deep, wide	4	.....	.....
22. Twist, plump, deep	5	.....	.....
23. Legs, straight, short, strong; shank fine, smooth	1	.....	.....
Wool — 12 per cent:			
24. Quantity, long, dense, even	4	.....	.....
25. Quality, fine, pure; crimp close, regular, even	4	.....	.....
26. Condition, bright, sound, clean, soft, light	4	.....	.....
Total	100	.....	.....

2. **The cuts of mutton and lamb.** — The cuts of mutton and lamb should be studied as the beef cuts were in a previous exercise. Refer to Illinois Station Bulletin 147.

3. **Handling of sheep.** — Practice catching, holding, and leading sheep as described in paragraph 204.

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CHAPTER XX

SWINE

Lard-type swine.
Berkshire, Poland-China, Chester White, Duroc-Jersey, Hampshire.
Bacon-type swine.
Large Yorkshire, Tamworth.
Regions for hog-raising.
Feeds for swine.
Sanitation in the hog lot.
Hog cholera.
Mineral matter and tonic for hogs.

MANY farmers in the Central States have become prosperous raising swine. One farmer in Illinois sells $10,000 worth of pure-bred swine each year in addition to other products from his farm. This is in the corn-belt region; we have already found that maize and cattle and hogs go well together. In the South and East, also, swine production on farms is extensive. Pork, bacon, lard, and other swine products, are staple articles of household use. A great impetus has been given to swine production in recent years by the Boys' Pig Clubs, which, like the Boys' Corn Clubs, the Girls' Tomato Clubs, and the Girls' Canning Clubs, have been fostered by the United States Department of Agriculture. For information about Pig Clubs, consult Farmers' Bulletin 566 given as a reference at the end of this chapter; also consult your county agent.

205. Lard-type swine. — Two types of swine are grown by American farmers. These are known as the lard- or fat-hog type, and the bacon-hog type. Lard-type swine produce large quantities of fat. They are low-set, wide, deep, and of

medium length, have well developed hams and shoulders, and give a fair quantity of bacon. They furnish the market with cheap side meat, hams, and shoulders. The animals are best suited to conditions where corn is cheaply and abundantly

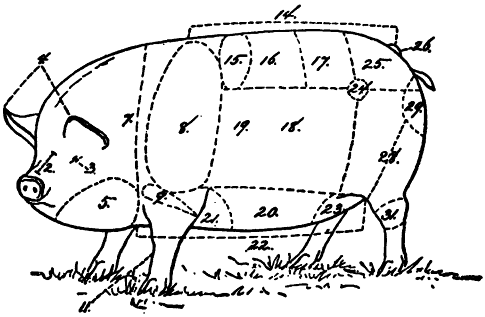

FIG. 179.—Points of the hog, three-quarters front view. 2, face; 3, eye; 4, ears; 5, jowl; 7, shoulder vein, or neck vein; 8, shoulder; 9, arm; 11, leg; 14, topline; 15, crops; 16, back; 17, loin; 18, side; 19, ribs; 20, belly; 21, fore flank; 22, underline, or bottom line; 23, hind flank; 24, hip; 25, rump; 26, tail; 28, thigh; 29, buttock; 31, hock.

produced. The chief breeds are Berkshire, Poland-China, Chester White, Duroc-Jersey, and Hampshire. Three of these originated in America and two in England. The external parts of swine are illustrated in Figs. 179 and 180.

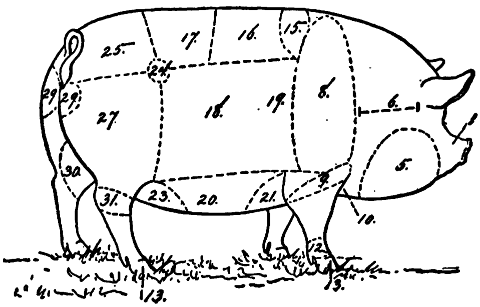

FIG. 180.—Points of the hog, side view. 1, snout; 5, jowl; 6, neck; 8, shoulder; 9, arm; 10, breast, or brisket; 12, pastern; 13, feet; 15, crops; 16, back; 17, loin; 18, side; 19, ribs; 20, belly; 21, fore flank; 23, hind flank; 24, hip; 25, rump; 27, ham, or gammon; 29, buttocks; 30, twist, or crotch; 31, hock.

Berkshire. — One of the oldest breeds of swine is the Berkshire (Fig. 181). This is an English breed and the animals are widely distributed in America, where they are very popular. They are blue-black in color and most of them show six white points — one on the face, the tip of the tail, and the four feet. An occasional splash of white is found on the forelegs. A solid black color or white spots on the body are objected to by breeders. In size the animals are a trifle larger than the other lard breeds. A mature boar, when fat, should weigh five hundred pounds and a mature sow, four hundred pounds. The conformation is that of the lard-type hog. The face is short and dished and the ears are short, pointed, and usually erect. The Berkshire has been largely used for crossing with scrub stock, as the animals work marked improvement in the offspring with whatever stock they are crossed. In the corn-belt states and in the South, Berkshires are very popular.

Fig. 181. — Berkshire sow.

Fig. 182. — Poland-China sow.

Poland-China. — This breed (Fig. 182) originated in the Miami Valley in Ohio as a result of crossing native hogs with Berkshires. Careful selection of the offspring followed with the result that to-day the Poland-China is a fixed type. The animals are found in all parts of the country, but more especially

in the corn-belt. The color in the best specimens is jet black, with six white points — at the tip of the tail, the four feet, and on the nose or the point of the lower jaw. In size they are nearly as large as the Berkshires. The conformation of the animals, like that of the Berkshires, is of the lard type. The head is short and the face shows a slight dish. A distinguishing feature is the ears. As described by the National Association of Expert Judges of swine, they should be "attached to the

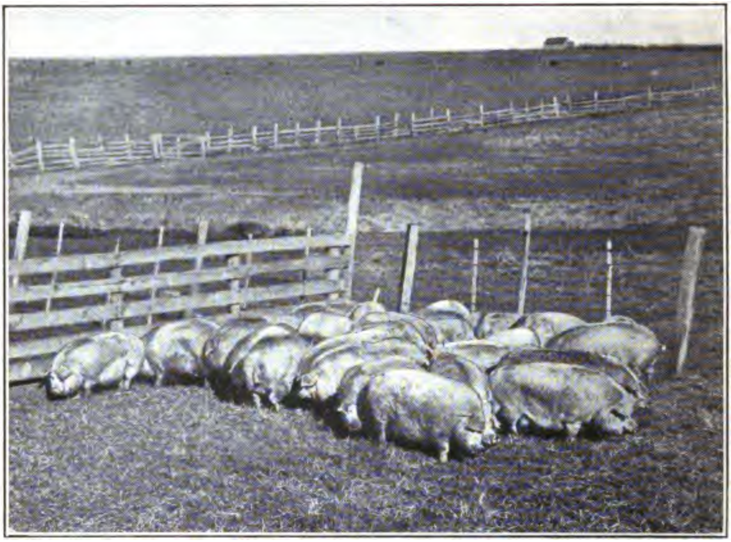

Fig. 183. — Chester White swine.

head by a short, firm knuckle . . . standing up slightly at the base to within two-thirds of the tip, where a gentle break, or drop, should occur. . . ."

Chester White. — As the name indicates the Chester White (Fig. 183) is a white breed. There are three different strains, known as the original Chester White, Todds' Improved Chester White, and Ohio Improved Chester White. The original Chester Whites are natives of Chester County, Pennsylvania,

and are the result of crossing native white swine with white hogs from Europe. The Todd strain was developed by Todd brothers, the foundation stock being a white and black boar from England mated with a white sow. The Ohio Improved strain was started by breeding and selecting the original Chester Whites with the purpose of securing animals of larger size and superior quality. The animals of the different strains are now found in most parts of the United States and Canada. They are white in color, usually with blue specks, known as freckles, on the skin. In size they rank with the Poland-Chinas and in conformation, they are somewhat longer, but usually show less width. The face is long and straight, the ears, drooping and falling gradually forward, not standing from the head as in the Poland-Chinas.

FIG. 184.—Duroc-Jersey sow.

Duroc-Jersey.—By crossing the Durocs and the Jersey Reds, swine found in New York and New Jersey, the Duroc-Jersey breed (Fig. 184) was originated. At first the animals had several undesirable qualities, but these have been improved by careful selection. The breed is very popular in the corn-belt states. In color the animals are red, a cherry red being preferred to lighter shades. In size they rank with Poland-Chinas and Chester Whites. In conformation they are low-set, broad and deep with full, smooth hams and shoulders. The head is of medium size, the face slightly dished, the ears, of medium size and point outward, forward, and slightly downward.

Hampshire.—The breed known as the Hampshire, or Thin Rind, originated in England. The animals have been classed as

both lard and bacon types, but now at the live-stock shows, they are usually shown in the fat-hog classes. In color they are black with a broad white stripe around the body and on the forelegs (Fig. 185). The weight of the animals is usually a little less than that of the other lard-type breeds. In conformation they are intermediate between lard and bacon hogs. The head is rather long, the face straight, and the ears erect and pointing forward.

FIG. 185. — **Hampshire boar.**

206. Bacon-type swine. — This type produces bacon in relatively large quantities. They have light hams and shoulders, but give a large proportion of bacon of good quality. They are inclined to be thin, narrow-bodied, long, deep, and upstanding. This type is best suited to conditions where peas, barley, and oats are produced abundantly and cheaply. The breeds of bacon-type swine are Large Yorkshire and Tamworth. Both are native to England.

FIG. 186. — **Yorkshire sow.**

Large Yorkshire. — One of the oldest English breeds is the Large Yorkshire (Fig. 186). The color is white with bluish spots on the skin. In size the animals surpass those of all other breeds, individuals sometimes weighing one thousand pounds. In conformation the Large Yorkshire is typically a

bacon-type hog. The sides are long and deep, the shoulders, thin and tapering, the head of medium length, the face, dished, the ears, long and carried erect.

Tamworth. — One of the oldest English breeds in existence is the Tamworth. In America the breed is found principally in the Eastern part of Canada, with scattered herds throughout the United States. The color is cherry red, and in size the animals rank next to the Yorkshires. In conformation they are of the true bacon type with long, deep, narrow bodies set on long legs. The snout is long and straight with no dish in the face and the ears are long, pointed, and erect.

207. Regions for hog-raising. — The corn-belt states have for a long time held first place in the number of hogs due largely to the cheapness and abundance of the corn in that region. Corn for hogs is a nutritious and palatable feed and gains in weight are easily induced by its use. In the corn-belt states where steers are fattened, hogs are usually allowed to follow the steers, — that is, stay in the same inclosure and pick any feed dropped by them. The feeding of steers is more profitable when hogs are kept and the latter usually give more profit than if fed alone. Nearly all farmers give the hogs corn in addition to that which they secure from the feed-lot and this ration is fed to them in separate yards. Corn should not be fed as the exclusive grain of hogs, as it is too heating and fattening. Feeders balance he ration by including such stuffs as shorts, bran, linseed meal, and tankage.

Hogs are raised not only in the corn-belt, but in all sections where barley, wheat, oats, or rye and such leguminous seeds as peas and beans can be produced cheaply and abundantly. Dairy regions are well adapted to pork-raising, as the dairy by-products are excellent feeds for the hogs.

The South has many features that make it suitable for pork-raising and the industry is increasing in that section. In Farmers' Bulletin 411, *Feeding Hogs in the South*, the following statements are made:

1. Hogs can be raised at a profit in the South, and southern farmers should raise more of them.

2. Hogs can not be raised profitably on corn alone.

3. While pork can sometimes be made at a profit when corn is supplemented with nothing but a concentrated feed, still it is not wise to use concentrated supplements alone.

4. Hogs can be produced cheaper when pastures are used along with the grains than when grains are used alone. By means of pasture crops pork can be made cheaper in the South than it is possible to make it in the corn belt.

5. The advantages arising from the use of pastures are:

Pork costs only one third to one half as much when pastures are used as when concentrated feeds alone are used.

The soils are improved very materially as a result of growing the legumes for the hogs and feeding extra grains to the animals.

The crops are harvested (through the hogs) without danger of loss from rains and without expense.

The hogs are under favorable health conditions; therefore losses from disease will be lessened.

208. Feeds for swine. — In addition to the concentrates which have been mentioned in the preceding paragraphs, swine require succulent feed as a part of their ration. Where white potatoes and sweet potatoes are grown abundantly, there is usually some unmarketable produce that can be utilized as hog feed. Mangels and pumpkins make good succulent feeds for swine. Whenever possible hogs should be on pasture. Alfalfa, red clover, crimson clover, and rape make suitable pastures for hogs. In the South, bur clover and Bermuda-grass are much used as hog pasture. Skim-milk and buttermilk are excellent for swine.

209. Sanitation in the hog lot. — The hog is subject to four very serious troubles: hog cholera, swine plague, tuberculosis, and animal parasites. In dealing with these, preventive measures must be adopted. The animals must be given dry, well ventilated quarters that are kept clean. Feed troughs and drinking places must be clean and the water pure. At least once a month the quarters should be disinfected by spraying

with a 5 per cent solution of crude carbolic acid followed by a coat of whitewash.

Hogs often suffer from lice. The insects are most numerous around the ears, inside the legs, and in the folds of the skin. In light cases they may be destroyed by washing the hogs with a broom moistened with an emulsion of kerosene and water, or by using a stock dip. In severe cases the whole herd should be dipped. If the herd is badly infested, the bedding should be burned and the loose boards and partitions of the quarters removed and the whole place disinfected with crude carbolic acid followed by a coat of whitewash.

The mud-wallow too often seen in hog yards should be done away with and a concrete wallowing place provided. This should be about fourteen inches deep and be built under cover of a shed. The ground surrounding it should be surfaced with crushed rock or concrete to prevent the formation of mud-holes. The tank should be partly filled with water and should be cleaned whenever it becomes dirty. Crude oil poured on the water will keep the hogs free from lice.

210. Hog cholera. — This is by far the most serious disease of hogs. It destroys about 90 per cent of all the hogs that die of disease in the United States. Nearly 7,000,000 hogs have died in one year and the money loss has averaged about $30,000,000 a year for the past forty years. Hog cholera is highly contagious and is caused by a germ which is carried easily from sick animals to healthy ones.

Methods for the prevention and treatment of the disease are fully outlined in Farmers' Bulletin 834 and this pamphlet should be secured and studied carefully by all those particularly interested in the subject. The following statements are from this bulletin:

With the object of assisting the farmer to protect himself the following suggestions are offered: Hog houses, lots, and pastures should be located away from streams and public highways, and the houses and lots should be arranged so that they may be cleaned and dis-

infected readily. They should be exposed as far as possible to sunlight, which is the cheapest and one of the best disinfectants. Hog lots should not be used for yarding wagons and farm implements and should not be entered with team and wagon, particularly when loading stock for shipment to market and when returning from stockyards and public highways. No one should be allowed to enter hog lots unless there is assurance that he does not carry infection. Farmers and their help should disinfect their shoes before entering hog lots after returning from public yards, sales, and neighboring farms.

Wallow holes and cesspools should be drained, filled in, or fenced off.

Runs underneath buildings should be cleaned and disinfected and then boarded up. Straw stacks that have been frequented by sick hogs should be burned or removed to the field and plowed under. In fact, it is a dangerous practice to leave remnants of stacks from year to year, and new tenants should beware of this source of danger.

Hogs that do not recover fully from cholera should be destroyed, as they remain constantly dangerous.

All animals that die on the farm, as well as the entrails removed from animals at butchering time, should be properly disposed of by burning to ashes, or by burying with quicklime away from streams and low places. Unless disposed of in this way they will serve to attract buzzards, crows, and dogs that may bring or carry away the germs of hog cholera.

Newly purchased stock, stock borrowed or loaned for breeding purposes, and stock exhibited at public fairs should be placed in isolated pens and kept there for at least fifteen days before being turned in with the herd. During this quarantine care should be used to prevent carrying infection from these to other pens by those who feed or care for stock.

Hogs should not be allowed to follow newly purchased stock unless such stock has been dipped or driven through a suitable disinfectant.

If hog cholera appears on the farm a notice should be posted at the entrance to the premises reading "HOG CHOLERA — KEEP OUT," and all neighbors should be warned so that they may protect their herds. The infected herd should be confined to limited quarters that can be cleaned daily during the presence of the disease and sprayed occasionally with a disinfectant consisting of one part of compound cresol solution to thirty parts of water, or with a recognized substitute therefor.

Up to the present time no drug or combination of drugs is known which can be regarded as a preventive or cure for hog cholera in a

true sense of the word. It is true that a number of preparations on the market composed of drugs and chemicals are advertised to protect hogs against cholera or to cure hogs affected with cholera. Many of these so-called cures have been tested by Federal or state institutions, and one and all have been found to be worthless. Farmers therefore are warned against investing their money and placing their faith in hog-cholera medicines. Only one agent known can be regarded as a reliable preventive. That agent is "anti-hog-cholera serum," prepared according to the methods originally worked out by the Bureau of Animal Industry. This serum is prepared as follows:

Hogs that are immune against cholera, either naturally, as a result of exposure to disease, or as a result of inoculation, are injected with large quantities of blood from hogs sick of cholera. The blood, which contains the virus from the sick hogs, even in minute quantities, would kill susceptible pigs but does not injure immunes; on the contrary, it causes immunes to become more highly immune. After the immunes are injected with virus as stated, they are called "hyper-immunes." About ten days or two weeks after an immune has been hyper-immunized, its blood contains a large amount of protective substances or antibodies, and it is from such blood that anti-hog-cholera serum is prepared.

Two systems are used in protecting hogs from cholera by inoculation — the "serum-alone inoculation" and the "simultaneous inoculation." The serum-alone inoculation consists merely in injecting, underneath the skin with a syringe, the serum which is obtained from hyper-immunized hogs. The serum may be used either to immunize healthy hogs or to treat those that are sick of cholera. Good serum, properly administered, is incapable of causing any harm to the treated animals. It does not contain the germs of hog cholera and therefore can not start an outbreak of cholera, even when the methods of application are faulty or the serum is of low potency. It is in the safety of this method of treatment that its chief advantage lies.

This method is always to be recommended in preference to any other for treating sick hogs. Unfortunately, in healthy hogs not infected with cholera it does not produce a permanent protection. If it did it would certainly be the only method to be recommended. The length of protection which follows the injection of serum alone seems to depend to a certain extent on the peculiarities of individual hogs, which can not be determined beforehand, and also to some extent on the dose of serum. Certain experiments have indicated that the immunity lasts somewhat longer in hogs which receive exceptionally large doses. Ordinarily a farmer may count on the immunity lasting

at least three or four weeks following the treatment of healthy hogs with serum alone. This immunity seems to last longer in old hogs than in young pigs. In some cases it apparently produces immunity which lasts for two or three months. At times, when healthy hogs are treated with serum alone and shortly thereafter exposed to cholera, they seem to acquire a permanent immunity, but this is not always the case, and therefore serum alone can not be depended on to produce a lasting immunity even though the treated pigs be promptly exposed to cholera.

It has been stated that serum alone can be used to treat sick hogs. This is true within certain limitations. Ordinarily it is efficacious in the very early stage of the disease, but apparently has only slight effect when the disease has advanced so that a hog shows visible signs of sickness, such as weakness, lack of appetite, and sluggishness.

The quantity of serum required for producing immunity or for curing infected animals is influenced by a number of conditions, chief among these being the condition and susceptibility of the pigs and the strength or potency of the serum which is used. No hard and fast rule can be laid down, but as a sort of general guide the doses given below are suggested:

Doses for Serum-alone Inoculation

Weight of Hog	Dose of Serum
Below 10 pounds	10 cubic centimeters.
10 to 15 pounds	15 cubic centimeters.
20 to 30 pounds	20 to 25 cubic centimeters.
40 to 75 pounds	30 cubic centimeters.
100 to 150 pounds	40 to 60 cubic centimeters.
175 pounds and over	80 cubic centimeters.

If the herd is infected the dose of serum should be increased slightly for all apparently well hogs, and all hogs showing high temperatures or other evidence of disease should receive at least a dose and a half of serum.

In the simultaneous method of inoculation, hog-cholera virus is used in addition to the serum. It has been stated above that the serum alone produces an immunity which lasts for only a very short time. The theory of the simultaneous inoculation is to administer the germs of hog cholera in the virus and at the same time to give a dose of serum which will protect the hogs from cholera. The virus

enters the system of the hog and causes a reaction which results in immunity like that which is found in hogs that recover from a natural attack of the disease. The serum being given at the same time prevents death or serious sickness which would otherwise be caused by the virus, and through the combined action of these two agents the hogs are rendered immune against cholera for life.

In administering the simultaneous inoculation the serum is injected in the manner already explained, and the virus is injected in the same manner but on the opposite side of the body. The virus, of course, is given in a very small dose as compared with the serum. The doses for simultaneous inoculation are indicated below.

DOSES OF SERUM AND VIRUS IN SIMULTANEOUS INOCULATION OF HEALTHY HOGS

WEIGHT OF HOGS	DOSE OF SERUM	DOSE OF VIRUS
Below 10 pounds	10 cubic centimeters	
10 to 15 pounds	15 cubic centimeters	¼ cubic centimeter.
20 to 30 pounds	20 to 25 cubic centimeters	½ cubic centimeter.
40 to 75 pounds	30 cubic centimeters	1 cubic centimeter.
100 to 150 pounds	40 to 60 cubic centimeters	2 cubic centimeters.
175 pounds and over	80 cubic centimeters	2 cubic centimeters.

If the herd is infected, the dose of serum should be slightly increased for all apparently healthy hogs, and all those showing high temperature or other evidence of disease should receive at least a dose and a half of serum and no virus.

While the serum alone has the advantage of being harmless, it should be remembered that it has the disadvantage of producing only a transitory immunity. The conditions are precisely reversed in the case of the simultaneous inoculation. In this case the immunity is prolonged, and it is rare to find a hog which has been immunized properly by the simultaneous method which again becomes susceptible to cholera. The principal objection to the simultaneous inoculation is the element of danger caused by the injection of the virus of cholera. If the serum should not be of proper strength, or if a sufficient dose of serum should not be administered, or if the work is not done properly, a case of hog cholera may be produced. Sufficient work, however, has been done to show that the simultaneous inoculation can be administered with safety. Certain important things are to be re-

membered in this connection. Use good serum, and give plenty of it. Enough serum should be given to prevent any signs of illness in the treated hogs. To get a lasting immunity it is not necessary to render the hogs visibly sick from the injection. Apparently just as firm immunity is secured when hogs show no symptoms of illness as when they are made sick by the injection. This treatment should be handled carefully, and those who have studied this question agree that the simultaneous inoculation should be administered only by competent veterinarians or by skilled laymen who have had adequate training in its use.

The United States Department of Agriculture does not prepare anti-hog-cholera serum for sale or distribution. For information as to where serum may be obtained and the help that may be had in combating hog cholera, write the Bureau of Animal Industry, United States Department of Agriculture, Washington, D. C., or the State Veterinarian, Live Stock Sanitary Board, or State Agricultural College of your state.

211. Mineral matter and tonic for hogs. — It is good practice to have before the hogs at all times a mixture of mineral substances. One made of four parts wood-ashes, one part salt, and one part sulfur is recommended. Another is made of four parts wood-ashes, one part salt, one part iron sulfate, and two parts air-slaked lime.

A tonic recommended by the United States Department of Agriculture as a powder condition, consists of the following ingredients thoroughly mixed:

	Pounds
Wood charcoal	1
Sulfur	1
Sodium chloride	2
Sodium bicarbonate	2
Sodium hyposulfite	2
Sodium sulfate	1
Antimony sulfide (black antimony)	1

The powder is given with the feed in the proportion of a tablespoonful to each two hundred pounds of weight not oftener than once a day.

QUESTIONS

1. Distinguish between lard-type and bacon-type swine.
2. Contrast the Poland-China and the Berkshire breeds.
3. Which breeds of swine are well suited to conditions in the corn-belt states?
4. Contrast the Large Yorkshire and the Tamworth breeds.
5. How can you tell a Chester White from a Large Yorkshire, a Duroc-Jersey from a Tamworth, a Poland-China from a Berkshire?
6. Tell some reason why hogs can be produced profitably in the South.
7. Name some plants that make good pasture for swine.
8. What preventive measures must be taken to keep swine healthy?
9. Tell how to make a concrete hog-wallow.
10. Give formulas for mineral mixtures for hogs.

EXERCISES

1. **Scoring and judging lard-type hogs.** — Score and judge hogs as directed for this work with the other classes of live-stock using the score-card below, or one from some other source.

SCORE-CARD FOR FAT LARD-TYPE HOGS[1]

SCALE OF POINTS	STANDARD	POINTS DEFICIENT	
		Student's Score	Corrected
General appearance — 30 per cent:			
1. Weight, score according to age	4	.....	.....
2. Form, deep, broad, medium length; smooth, compact, symmetrical; standing squarely on medium short legs	10	.....	.....
3. Quality, hair smooth and fine; bone medium size, clean, strong; general appearance smooth and refined	6	.....	.....
4. Covering, finished; deep, even, mellow, free from lumps and wrinkles	10	.....	.....

[1] From Purdue University Circular 29.

SCORE-CARD FOR FAT LARD-TYPE HOGS (*Continued*)

Scale of Points	Standard	Points Deficient: Student's Score	Points Deficient: Corrected
Head and neck — 8 per cent:			
5. Snout, medium length, not coarse	1	.....	.....
6. Eyes, not sunken, clear, not obscured by wrinkles	1	.....	.....
7. Face, short; cheeks full	1	.....	.....
8. Ears, fine, medium size, attached neatly	1	.....	.....
9. Jowl, full, firm, neat	2	.....	.....
10. Neck, thick, short, smooth to shoulder	2	.....	.....
Forequarters — 12 per cent:			
11. Shoulders, broad, deep, smooth, compact on top	8	.....	.....
12. Breast, full, smooth, neat	2	.....	.....
13. Legs, straight, short, strong; bone clean; hard; pasterns short, strong, upright; feet medium size	2	.....	.....
Body — 33 per cent:			
14. Chest, deep, wide, large girth	4	.....	.....
15. Sides deep, full, smooth, medium length	8	.....	.....
16. Back, broad, strongly arched, thickly and evenly covered	9	.....	.....
17. Loin, wide, thick, strong	9	.....	.....
18. Belly, straight, smooth, firm	3	.....	.....
Hindquarters — 17 per cent:			
19. Hips, wide apart, smooth	3	.....	.....
20. Rump, long, level, wide, evenly fleshed	3	.....	.....
21. Ham, heavily fleshed, full, firm, deep, wide	9	.....	.....
22. Legs, straight, short, strong; bone clean, hard; pasterns short, strong, upright; feet medium sized	2	.....	.....
Total	100	.....	.....

2. **Scoring and judging bacon-type hogs.**[1] — In sections where bacon swine are important a special score-card should be used for this type.

[1] From Agricultural Education Monthly, No. 7, Vol. II, U. S. Department of Agriculture.

The following description will aid in adapting the score-card and description of the lard hog to the bacon type.

Form. — The form of swine of the true bacon type is apparent at a glance, especially in contrast with the lard type. The bacon hog has a longer body than the lard type, showing less thickness and depth. Associated with the longer body are longer legs and snout.

Quality. — Although the bacon hog may have a coarser bone it is marked by more refined quality than the hog of lard type. The hair should be fine and silky and lie close to the body. The head and legs should present a trim, clear-cut appearance.

Condition and weight. — A thin hog of a lard type cannot be sold to advantage on a market which requires Wiltshire sides, because it will lack the characteristic finish demanded for such bacon. There should be an interspersing of fat and lean with a covering of 1 to 1½ inches of fat. This covering should give the carcass a smooth, firm finish. The weight most acceptable for bacon hogs is from 180 to 190 pounds, although weights above and below these are accepted.

Head and neck. — This type is characterized by a longer neck and snout than the lard type. The jowl is also lighter and neater. A neck too long indicates a poor feeder, while a very short neck with a full jowl indicates a tendency to put on fat.

Forequarters. — The shoulders should not be prominent but lie in close to the body, having good width and depth with ample covering of flesh. The breast should not be full.

Body. — The chest of a bacon hog is deep and full but not too broad. Although the back carries the most valuable meat it should not be very broad, as a broad back denotes a tendency to fatten. The width should be the same from shoulder to ham. The sides are of most importance in hogs of this type as this portion is depended upon for bacon. The side should be of moderate depth and as long as is consistent with strength in the back. A sway back is objectionable. The sides should be smooth, free from all wrinkles and seams.

Hindquarters. — There is not the extreme development in the hindquarters that there is in the lard hog. The rump should be level, long, and moderately broad. The hams are long, and tapering, being relatively thin but broad from front to rear. Although the legs are longer than in the lard type they should be clean-cut, showing bone smooth, clean, and hard. It is important that the legs be straight and placed well at the four corners of the body, with strong pasterns to support a good weight.

3. **Cuts of pork.** — Make a study of the cuts of pork in the same manner as directed for beef and mutton. Refer to Illinois Bulletin 147.

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CHAPTER XXI

POULTRY

Types of poultry.
Breeds of chickens.
- Egg breeds.
- General-purpose breeds.
- Meat breeds.

Poultry houses.
Natural incubation.
Natural brooding.
Artificial incubation.
Artificial brooding.
Feeding for egg production.
Feeding for meat production.

THE importance of poultry can scarcely be realized. Six hundred million dollars are brought annually to the farmers of the United States for eggs alone, and there is a similar proportion in Canada. Much of this revenue goes to the large poultry-raising establishments, but a very considerable part of it also goes to those farmers that keep only a few hens as an incident of their business. There is no live-stock so well adapted to so many farm conditions as is poultry. There is also special fascination in the rearing of fowls. Young people are particularly interested in it, and all the products are wanted on the table or find a ready demand in the market. The Boys' and Girls' Poultry Clubs have been a great incentive to poultry raising. In many of the states the federal or state government pays an expert poultry-man to devote all of his time to the furthering of this work. The county agent will tell you how to reach him. There is a very attractive popular literature on poultry raising.

212. Types of poultry. — Chickens are classified in two ways, according to the origin of the breed and according to the utility of the fowls. As to breed, they are listed as Mediterranean, American, Asiatic, English, Belgian, French, German, Dutch, and Polish with special classes including game, Bantams, Silkies, Sultans, and Frizzles. From the utility standpoint they are classified as egg, general-purpose, meat, and

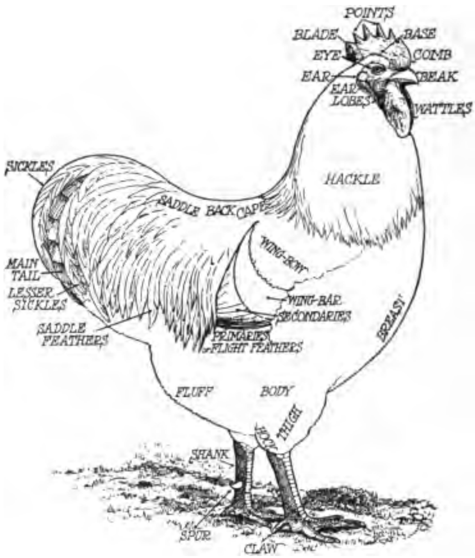

Fig. 187. — Glossary chart giving the names of the various sections of a male fowl.

ornamental, or fancy, breeds. For school work this classification from the utility standpoint is especially applicable and is the one considered here. As with the other classes of livestock, the external parts of the fowl should be studied. Fig. 187 is from a drawing prepared by the United States Department of Agriculture and shows these parts very clearly.

The general term poultry includes, besides chickens, ducks,

geese, Guinea fowls, peafowls, and turkeys. In the United States, chickens are by far the most important class, poultry as a whole being approximately 95 per cent chickens, 1.5 per cent geese, 1 per cent turkeys, slightly less than 1 per

Fig. 188. — Light Brahma male. Most popular of the meat type. Fair layers of large brown eggs.

cent ducks, and the remaining classes together about 1.5 per cent.

Fowls of the meat type (Figs. 188 and 189) have a short, wide back, a well developed breast, a box-like body, and carry a large quantity of flesh. Fowls of the egg type (Fig. 190) have long backs, full chests, and well developed abdomens; this form is conducive to egg-producing capacity and stamina.

Fowls of the general-purpose, or utility, type (Figs. 191, 192, 193) show a conformation somewhat between the meat and egg types. They are bred to produce more eggs than the fowls of the meat type and more meat than the fowls of the egg type. They may be considered to be dual-purpose animals.

Fig. 189. — Buff Cochin male, showing the feathering of the legs and toes. Meat type of poultry.

Prolificacy of egg-production is often indicated by the size of the comb, small combs usually being found on the birds of the meat type, large combs on those of the egg type, and medium-sized combs on those of the general-purpose type. The differences can be seen in the pictures already referred to.

The habits of the different types of fowls vary considerably. Birds of the meat type are slow movers and of a quiet disposition, tendencies that are conducive to fat. They may be likened to beef animals in this respect. Fowls of the egg type are nervous, alert, active, and constantly foraging for food. They are similar in disposition to dairy cows that show nervous temperament. Fowls of the general-purpose type show a blending in disposition of the other two; they are not so slow-moving as the meat type and not so alert as the egg type.

FIG. 190. — White Leghorn male. The most popular breed for commercial poultry farms. The hens are non-sitters; they make excellent summer layers, and when cared for properly make good winter layers.

FIG. 191. — Barred Plymouth Rock male, showing the barring desired in this popular breed of general-purpose fowl. Barred Rocks mature early and are good winter layers.

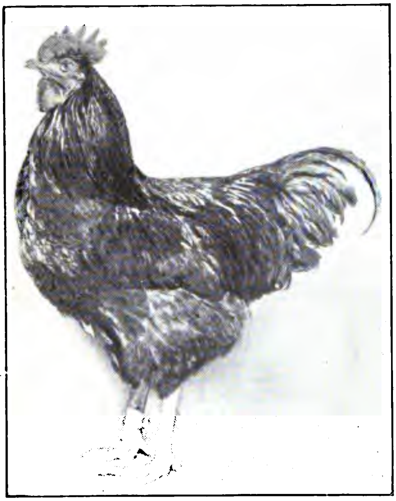

FIG. 192. — Rhode Island Red male, showing the long back and low carriage of tail desired in this popular general-purpose breed.

FIG. 193. — White Wyandotte male. A bird made up of curves. The hens are good winter layers and the cockerels are in demand for broilers.

213. Breeds of chickens. — The Standard of Perfection, the publication of the American Poultry Association, lists thirty-eight breeds and one hundred four varieties of chickens, including both utility and fancy fowls. In Table XV are given the names of the utility breeds and varieties most commonly found in the United States, their native home, and the color of the egg-shells.

TABLE XV

AMERICAN BREEDS OF CHICKENS

EGG BREEDS

Breed	Variety	Native Home	Color of Egg-Shell
Leghorn . . .	Single-comb black Single-comb brown Rose-comb brown Single-comb buff Rose-comb buff Silver Single-comb white Rose-comb white	Italy	White
Ancona . . .	Mottled Single-comb	Italy	White
Andalusian . .	Blue	Italy	White
Minorca . . .	Single-comb black Rose-comb black Single-comb white	Italy	White
Spanish . . .	White-faced black	Spain	White
Hamburg . . .	Black Golden-penciled Golden-spangled Silver-penciled Silver-spangled	Holland	White
Campine . . .	Golden Silver	Belgium	White

TABLE XV (*Continued*)

GENERAL-PURPOSE BREEDS

Breed	Variety	Native Home	Color of Egg-Shell
Plymouth Rock .	Barred Buff Columbian Partridge Silver-penciled White	America	Brown or tinted
Wyandotte . .	Black Buff Columbian Golden-laced Partridge Silver-laced White	America	Brown or tinted
Rhode Island Red	Single-comb Rose-comb	America	Brown or tinted
Dominique . .	Rose-comb	America	Brown or tinted
Java	Black Mottled	America	Brown or tinted
Orpington . .	Single-comb buff Single-comb black Single-comb white	England	Tinted
Dorking . . .	Colored Silver-gray White	England	White
Houdan . . .	Mottled	France	White

MEAT BREEDS

Breed	Variety	Native Home	Color of Egg-Shell
Brahma . . .	Light Dark	India	Brown or tinted
Cochin . . .	Buff Partridge White Black	China	Brown or tinted
Langshan . . .	Black White	China	Brown or tinted

214. Poultry houses. — Two general types of houses for poultry are in use — the colony house and the continuous apartment house. Colony houses are small and are usually built on skids, or runners, and moved about from place to place as occasion demands. Continuous apartment houses are built where they are to stand permanently. Many different styles of houses of each type are in use. A farmer or a pupil desiring to build poultry houses will profit by corresponding with officers of his state experiment station and with the Division of Poultry Investigations of the Department of Agriculture at Washington from whom he can secure much information and plans for the buildings. Among the requirements to be considered in building poultry houses are: (1) they must be on well drained soils; (2) they should face the south or southeast; (3) they should be so built that they can be kept clean; (4) ventilation must be provided for; (5) room for a scratching place near the house must be available.

215. Natural incubation. — The hen should be moved from her regular laying nest at night and dusted thoroughly with insect powder before putting on the new nest. At first one or two china eggs should be put under her and a board placed in front of the nest to keep her from leaving. On the second day, in the evening, the board should be removed and feed and water placed where the hen can reach it. If she leaves the nest and after feeding returns to it, she really desires to sit. The china eggs should then be removed and those that are to be incubated substituted. During the period of incubation, twenty-one days, plenty of feed and water must be provided for the hen. At hatching time she should not be disturbed unless she becomes restless and pecks at or steps on the chicks, in which case the chicks that are hatched should be removed as soon as they are dry, placed in a basket that is lined with a piece of wool cloth, and put in a warm place. When all of the eggs are hatched, these chicks are put back with the hen and all removed to the brood coop.

The poultry specialists of the United States Department of Agriculture make the following suggestions about natural incubation:

"If several hens are sitting in the same room, see that they are kept on the nests, allowing them to come off only once a day to receive feed and water, the feed to consist of corn, wheat, or both. If there are any that do not desire to come off themselves, they should be taken off. Hens usually return to their nests before there is any danger of the eggs chilling, but if they do not go back in half an hour in ordinary weather, they should be put on the nest. Where a large number of sitters are kept in one room it is advisable to let them off in groups of from four to six at a time. The eggs and nests should be examined and cleaned, removing all broken eggs and washing those that are soiled; in the latter case the soiled nesting material should be removed and clean straw added. Nests containing broken eggs that the hen is allowed to sit on soon become infested with mites and lice. These cause the hens to become uneasy and leave the nest, and hence the loss of valuable sittings of eggs. In mite-infested nests the hen, if fastened in, will often be found standing over rather than sitting on the eggs.

"Many eggs that are laid in the late winter and early spring are infertile. For this reason it is advisable to set several hens at the same time. After the eggs have been under the hens from five to seven days, the time depending somewhat on the color and thickness of the shells — white-shelled eggs being easier to test than those having brown shells — they should be tested, the infertile eggs and dead germs removed, and the fertile eggs put back under the hen. In this way it is often possible to put all the eggs that several hens originally started to sit on under fewer hens and reset the others. For example, thirty eggs are set under three hens at the same time, ten under each. At the end of seven days we find on testing the eggs from all the hens that ten are infertile, which leaves us twenty eggs to reset, which we do by putting them under two hens

and have the remaining hen sit over again after she has sat only seven days. In this way considerable time can be saved in hatching operations.

"An egg, whether impregnated or not, has a small grayish spot on the surface of the yolk, known as the 'germinal spot.' As soon as a fertile egg is placed under a hen, or in an incubator, development begins. All eggs should be tested at least twice during the period of incubation, preferably on the seventh and fourteenth days, and the infertile eggs and dead germs removed. White eggs can be tested on the fourth or fifth day, while the development in eggs having brown shells often cannot be seen by the use of an ordinary egg tester until the seventh day. Dead germs soon decay and give off a bad odor, if allowed to remain under the hen. Infertile eggs make good feed for young chickens and are often used in the home for culinary purposes. Electric or gas lamps may be used in a box with a hole slightly smaller than an egg cut in the side of the box and at the same level as the light. They may also be tested by sunlight, or daylight, using a shutter or curtain with a small hole in it for the light to shine through.

"A good home-made egg-tester, or candler, can be made from a large shoe box, or any box that is large enough to go over a lamp, by removing the end and cutting a hole a little larger than the size of a quarter in the bottom of the box, so that when it is set over a kerosene lamp the hole in the bottom will be opposite the blaze. A hole the size of a silver dollar should be cut in the top of the box to allow the heat to escape.

"The eggs are tested with the large end up, so that the size of the air cell may be seen as well as the condition of the embryo. The testing should take place in a dark room. The infertile egg, when held before the small hole, with the lamp lighted inside the box, will look perfectly clear, the same as a fresh one, while a fertile egg will show a small dark spot, known as the embryo, with a mass of little blood veins extending in all directions, if the embryo is living; if dead, and the egg has

been incubated for at least forty-six hours, the blood settles away from the embryo toward the edges of the yolk, forming in some cases an irregular circle of blood, known as a blood ring. Eggs vary in this respect, some showing only a streak of blood. All infertile eggs should be removed at the first test. The eggs containing strong, living embryos are dark and well filled up on the fourteenth day, and show a clear, sharp, distinct line of demarcation between the air cell and the growing embryo, while dead germs show only partial development, and lack this clear, distinct outline."

216. Natural brooding. — Before moving the hen and chicks to the brood coops, she should be powdered with insect powder to get rid of the lice. The brood coop must be kept clean, and if mites are found, the coop should be sprayed with kerosene. An inch or so of sand or a thin layer of straw should be kept on the floor of the coop and the coop moved each day to fresh shady ground. As long as she will care for them the hen should be left with the chicks. The following directions from Farmers' Bulletin 624 will be found very satisfactory for feeding the chickens:

"As soon as the chickens will eat whole wheat, cracked corn, and other grains, the small-sized chick feed can be eliminated. In addition to the above feeds the chickens' growth can be hastened if they are given sour milk, skim-milk, or buttermilk to drink. Growing chickens kept on a good range may be given all their feed in a hopper, mixing two parts by weight of cracked corn with one part of wheat, or equal parts of cracked corn, wheat, and oats in one hopper and the dry mash for chickens in another. The beef scrap may be left out of the dry mash and fed in a separate hopper, so that the chickens can eat all of this feed they desire. If the beef scrap is to be fed separately it is advisable to wait until the chicks are ten days old, although many poultrymen put the beef scrap before the young chickens at the start without bad results. Chickens confined to small yards should always be

supplied with green feed, such as lettuce, sprouted oats, alfalfa, or clover, but the best place to raise chickens successfully is on a good range where no extra green feed is required. Fine charcoal, grit, and oyster shell should be kept before the chickens at all times, and cracked or ground bone may be fed where the chickens are kept in small bare yards, but the latter feed is not necessary for chickens that have a good range."

Young chickens should be fed from three to five times daily, depending on one's experience in feeding. Undoubtedly chickens can be grown faster by feeding five times daily than by feeding three times daily, but it should be borne in mind that more harm can be done to the young chickens by overfeeding than by underfeeding, and at no time should they be fed more than barely to satisfy their appetites and to keep them exercising, except at the evening or last meal, when they should be given all they will eat. Greater care must be exercised not to overfeed young chicks that are confined than those that have free range, as leg weakness is apt to result in those confined.

"The young chicks may be fed any time after they are 36 to 48 hours old, whether they are with a hen or in a brooder. The first feed may contain either hard-boiled eggs, johnnycake, stale bread, pinhead oatmeal, or rolled oats, which feeds or combinations may be used with good results. Mashes mixed with milk are of considerable value in giving the chickens a good start in life, but the mixtures should be fed in a crumbly mass and not in a sloppy condition. After the chickens are two months old they may be fed four times daily, and after three months old three times daily, with good results. Johnnycake composed of the following ingredients in the proportions named is a very satisfactory feed for young chickens: one dozen infertile eggs or one pound of sifted beef scraps to ten pounds of corn meal; add enough milk to make a pasty mash, and one tablespoonful of baking soda. Bake into a cake. Dry bread crumbs may be mixed with hard boiled eggs, making about one-fourth of the mixture of eggs, or rolled oats may be

used in place of the bread crumbs. Feed the bread crumbs, rolled oats, or johnnycake mixtures five times daily for the first week, then gradually substitute for one or two feeds of the mixture, finely cracked grains of equal parts by weight of cracked wheat, finely cracked corn, and pinhead oatmeal or hulled oats, to which about 5 per cent of cracked peas or broken rice and 2 per cent of charcoal, millet, or rape seed may be added. A commercial chick feed may be substituted if desired. The above ration can be fed until the chicks are two weeks old, when they should be placed on grain and a dry or wet mash mixture.

"After the chicks are ten days old a good growing mash, composed of two parts by weight of bran, two parts middlings, one part cornmeal, one part low-grade wheat flour or red-dog flour, and 10 per cent sifted beef scrap, may be placed in a hopper and left before them at all times. The mash may be fed either wet or dry; if wet, only moisture (either milk or water) should be added to make the feed crumbly, but in no sense sloppy. When this growing mash or mixture is not used a hopper containing bran should be accessible to the chickens at all times.

"When one has only a few chickens it is less trouble to purchase the prepared chick feeds, but where a considerable number are reared it is sometimes cheaper to buy the finely cracked grains and mix them together. Many chick feeds contain a large quantity of grit and may contain grains of poor quality, so that they should be carefully examined and the quality guaranteed before they are purchased."

217. Artificial incubation. — Lack of care and attention to details are responsible for the small hatches that so commonly result in artificial incubation. The following summary of directions by Harry M. Lamon in Farmers' Bulletin 585 is an excellent guide to those using incubators:

"Follow the manufacturer's directions in setting up and operating an incubator.

"See that the incubator is running steadily at the desired temperature before filling with eggs. Do not add fresh eggs to a tray containing eggs which are undergoing incubation.

"Turn the eggs twice daily after the second and until the nineteenth day. Cool the eggs once daily, according to the weather, from the seventh to the nineteenth day.

"Turn the eggs before caring for the lamps.

"Attend to the machine carefully at regular hours.

"Keep the lamp and wick clean.

"Test the eggs on the seventh and fourteenth days.

"Do not open the machine after the eighteenth day until the chickens are hatched."

218. Artificial brooding. — When the chickens are to be brooded artificially, they are usually left in the incubator without feed for twenty-four to thirty-six hours after hatching. After this period they are taken to the brooder which should have been in operation for a day or more at the proper temperature. The proper temperature during the time the chicks are in the brooder depends on how near the thermometer is to the source of heat, the age of the chickens, and the weather. Usually, the temperature for the first ten days will run from 90 to 100° F., averaging from 93° to 95°; for the next ten days, it should be reduced to 85°, and then as long as the chicks require heat be kept at about 75°. The brooder lamp, if one is used, should be cleaned every day, and the brooder should be inspected often to see whether it is at the correct temperature. The chickens are usually allowed to stay in the brooder until they are from six to ten weeks old, the exact time depending on the weather and the condition of the chickens.

Brooders in which hard coal is the source of heat are used on many poultry farms and seem to give satisfactory results. They are much easier to care for than the lamp type.

219. Feeding for egg production. — Hens require a narrow ration. Wheeler, from a large number of tests at the New York Experiment Station, has found that a ration having a

nutritive ratio of 1:4.2 gives good results. The natural feed of poultry consists of seeds, insects, green forage, and grit and to provide feeds similar to these, the chickens should be given grains, mill-products, meat-meals, skim-milk, oyster shells, green feed, and grit. The following mixtures are recommended by the Poultry Department of Cornell University, Ithaca, New York:

Grain

WINTER RATION

Wheat	60 pounds
Corn	60 pounds
Oats	30 pounds
Buckwheat	30 pounds

SUMMER RATION

Wheat	60 pounds
Corn	60 pounds
Oats	30 pounds

DRY MASH

Corn meal	60 pounds
Wheat middlings	60 pounds
Wheat bran	30 pounds
Alfalfa meal	10 pounds
Oil meal	10 pounds
Beef scrap	50 pounds
Salt	1 pound

The hens should eat about half as much mash by weight as whole grains. Good results are obtained by giving a light feeding of grain in the morning and a larger one in the afternoon. The grain is fed in straw spread on the floor of the pen to induce the fowls to take exercise. The quantity should be about what the fowls will clean up nicely. The mash is usually fed dry in a hopper and is kept before the hens all the time so they can help themselves at will. Succulent feed, also, should be available for the hens. Beets, cabbage, sprouted oats, and green clover are good for this purpose, when the fowls are kept in yards. Hens on free range will forage for succulence.

Grit, cracked oyster shells, bone, and charcoal should be kept in hoppers before the fowls at all times. They are necessary for egg-making and the grinding of the feed.

220. Feeding for meat production. — Fowls that are to be sold for meat should be fattened for at least ten days before they are put on the market. This will greatly improve the quality of the meat. They should be confined in small pens or crates during the feeding period; this prevents them from taking much exercise. Just before they are placed in the inclosures and twice during the fattening period, they should be dusted with insect powder to free them from lice. The ration should be a mixture of grains (usually ground) and animal products like meat meal and skim-milk. A ration that has been recommended is a mixture of corn meal, five parts (by weight), ground oats with hulls removed, one part, meat meal, one part, all moistened with sour milk and fed three times a day. The fowls must be brought to full feed gradually, starting with a small quantity the first day and increasing a little at each feeding until they are getting all they will eat. A week is usually required to bring them to full feed.

QUESTIONS

1. Describe the general conformation of the fowls of each of the three utility types.
2. Discuss the habits of fowls of the three types.
3. What two general types of poultry houses are in use? From whom can one secure information concerning the different kinds of houses?
4. State the requirements to be considered when building poultry houses.
5. What is meant by natural incubation of eggs? By artificial incubation of eggs?
6. Give directions for brooding chickens when a hen is used.
7. What kind of ration should be fed to laying hens?
8. Outline the method of feeding young chickens.
9. Tell how to test eggs for fertility.
10. What should sitting hens be fed?

Score-card for Utility Poultry[1]

Variety ....

Points	Perfect	Scorer's	Corrected
General appearance, 30 points:			
Weight, according to age	2	.....	.....
Form, long, moderately deep, broad, low-set, conforming to breed type, top line and under line straight	8	.....	.....
Condition, face and head appurtenances bright red, eye bright and full, feathers glossy, uniformly well fleshed throughout	6	.....	.....
Style, active and vigorous, not restless, showing strong character	7	.....	.....
Quality, bone moderately fine, feathers soft, skin and scales mellow, flesh fine texture, evenly distributed	7	.....	.....
Head and neck, 20 points:			
Head short, broad between the eyes, neither coarse nor snaky in appearance	5	.....	.....
Comb medium in size, bright in color, fine texture, and well attached	3	.....	.....
Beak short, stout, broad at the base, well curved	3	.....	.....
Eye clear and full	2	.....	.....
Face short, full, with a clean-cut appearance	2	.....	.....
Wattles and lobes medium in size, fine in texture, and smooth	1	.....	.....
Neck moderate in length, well joined to head and shoulders	4	.....	.....
Body and legs, 50 points:			
Shoulders broad and rather flat on top	4	.....	.....
Back broad, fair length, width well carried back	6	.....	.....
Breast moderately deep and wide, full and round	10		
Keel well forward, long and straight, well covered with flesh throughout	12	.....	.....
Tail well spread and full, no pinched effect	4	.....	.....
Thighs medium length, plump	6	.....	.....
Legs straight, fairly short, set well apart, strong but not coarse	8	.....	.....
Total	100	.....	.....

Remarks ....

Name of scorer .... Date ....

[1] From U. S. Department of Agriculture Bulletin 281.

EXERCISES

1. **Classes of poultry.** — The teacher should get for class observation two or three fowls of each of the utility types and place them in coops, or yards, near the school where they can be easily observed. Try to get fowls of about the same age. For the meat type, use Brahma, Cochin, or Langshan; for the general purpose type, Plymouth Rock, Wyandotte, Rhode Island Red, or Orpington; for the egg type, Leghorn, Minorca, or Hamburg. (See Figs. 188 to 193.)

2. **Scoring of poultry.** — Making use of the score-card given on the previous page, score several birds. This score-card is a very good one and is arranged from the utility standpoint.

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CHAPTER XXII

FARM MACHINERY

Lack of care of farm machinery.
Plows.
  Walking, sulky, gang, disc, subsoil.
Harrows.
  Disc, spring-tooth, spike-tooth, blade.
Cultivators.
  One-horse, straddle-row.
Weeders.
Planting implements.
  Broadcast seeders.
  Grain drills.
  Corn- and cotton-planters.
  Potato-planters.
  Transplanters.
Hay-harvesting machinery.
  Mowers.
  Rakes.
  Tedders.
  Loaders.
  Stackers.
  Harpoon forks and slings.
Small grain, corn, and potato harvesters.
Threshing machines.
Farm tractors.

In the days when the crooked stick was used as a plow and most of the farm labor was performed by hand, a man by his own efforts could crop only a very few acres. To-day with the aid of the many efficient machines one can farm a large acreage, which means increased crops. This gives more food for the nation and releases men for other kinds of work. There are

machines for practically every major kind of farm work and they are not very expensive considering the materials that enter into their construction. Farm machines not only save time, but often make possible the saving of a crop that by reason of rain or some other weather condition would be lost. How extensively machinery may be used on any farm will depend largely on size of farm, kind of product, and the labor supply. With the high price of labor on American farms, and the difficulty of securing it, machinery and labor-saving implements are much employed; yet it is easily possible to invest too much money in machinery in proportion to the available capital. The American ingenuity in farm machinery is well known, and is a source of pride.

221. Lack of care of farm machinery. — In the United States a very unfortunate condition found is the absolute lack of care which the farm machinery receives on many farms. This lack of care is seen in (1) improper handling of the machines while in use and (2) improper care while not in use. It too often happens that the operator of a machine will take it to the field for use when it is out of adjustment or when certain bolts and screws are out of place; this soon results in permanent injury and if continued the farmer finds it necessary to purchase a new machine. The operator should understand the working parts of the machine and be able to adjust them properly before using. Whenever a screw or bolt becomes loose, it should be tightened, the bearings should be kept well oiled, and all parts should work smoothly.

A properly equipped shop on the farm where minor repairs can be made is useful in keeping machinery in good condition. The shop need not be a separate building; it may be a part of a storage shed or a wagon house. It should not, however, be part of the barn, because of danger of fire from the forge.

Farm machinery should be protected from the weather. Exposure to weather for a season will do more harm to a machine than the wear caused by its use during the season.

On American farms the average life of a grain-binder, a machine costing about $125, is about five years. However, experience has shown that with proper care a binder will give efficient service for at least fifteen years. This same condition holds true with most farm implements.

A shed in which machinery can be stored should, like a shop, be a part of the equipment of every farm. It is poor policy to buy good machinery and convert it into worthless junk in a few years, because of the lack of a storage place.

222. Plows. — The most important implement on the farm is the plow, for by its use the soil is turned over and pulverized and made ready for forming the proper bed in which the

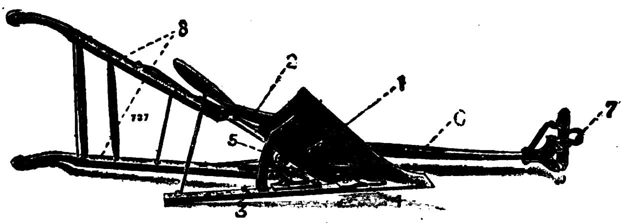

FIG. 194. — Bottom view of a walking plow. 1, share; 2, mold board; 3, landside; 4, frog; 5, brace; 6, beam; 7, clevis; 8, handle.

seed is to be planted. The first plows were crooked sticks that merely scratched the surface of the land. The next improvement was an implement that would turn the top soil over and expose it to the weather. This was followed by the modern plow that not only turns over the furrow-slice, but in the operation causes a shearing motion between the soil particles which aids in pulverizing the soil. This shearing action does much to improve the structure of the soil. The chief kinds of plows are walking plows, sulky plows, gang plows, disc plows, and subsoil plows.

Walking plows. — The so-called walking plows are usually drawn by one or two horses. They can be obtained in a number of different types, depending on the purpose for which

FIG. 195. — **Sulky plow (reversible). An efficient implement for the general farm.**

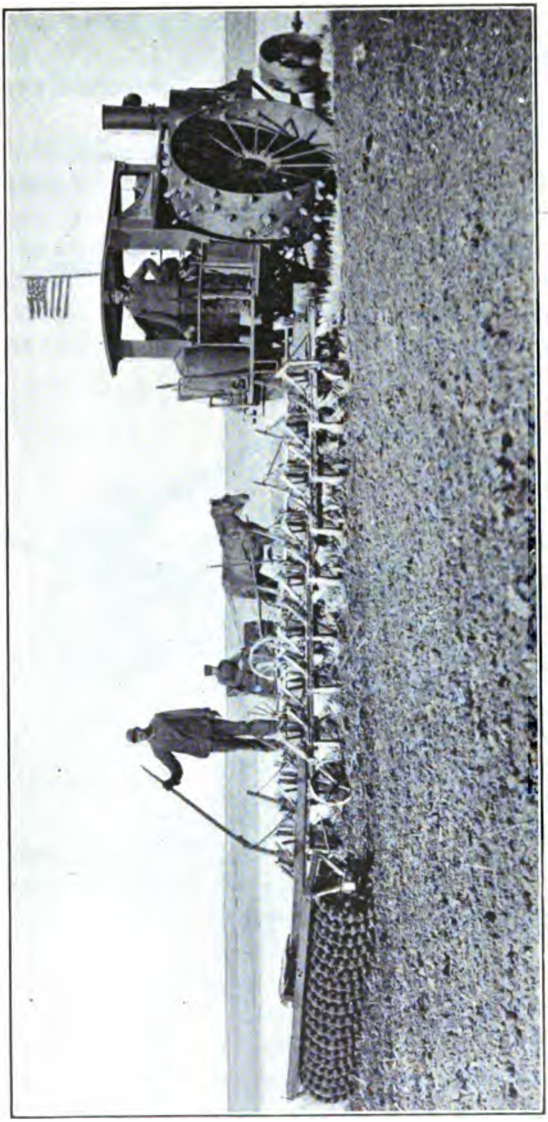

FIG. 196. — A ten-bottom gang plow with gasoline tractor.

they are to be used. More walking plows are found on American farms than any of the other types. Fig. 194 shows the parts of a walking plow. These should be learned by every one who ever expects to operate a plow.

Sulky plows. — Sulky plows are those attached to a frame set on wheels. The frame serves to regulate the depth of plowing. Usually there is a seat on the frame where the operator can ride. The implement shown in Fig. 195 is termed a reversible sulky plow. It is provided with two plow bottoms, right-hand and left-hand. When plowing back and forth across a field, one of these plow bottoms is used for a trip one way and at the end

FIG. 197. — Disc plow.

of the furrow the implement is turned and the other plow bottom used for a trip the other way of the field.

Gang plows. — Plows made to turn two or more furrows at once are known as gang plows (Fig. 196). They are moved by horses or tractors and are very efficient machines for rapid plowing. In Fig. 196 is pictured a ten-bottom gang plow propelled by a tractor and followed by a corrugated roller. An outfit like this will turn over much land in a day.

Disc plows. — A rotating disc is used instead of a curved moldboard in the disc plows (Fig. 197). These implements are especially useful in heavy soils and are popular in many localities.

Subsoil plows. — What are known as subsoil plows (Fig. 198) are employed to follow in the furrow made by a regular plow for the purpose of loosening the soil below the plow depth.

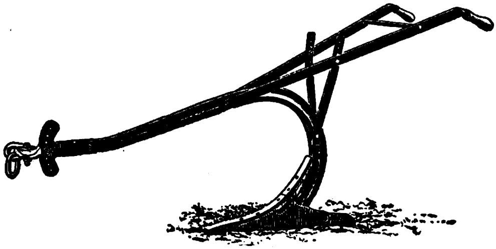

Fig. 198. — Subsoil plow.

They do not turn a furrow. In regions where hard-pan is found just below plow depth, subsoil plows are very efficient for increasing the depth of soil available for the roots.

Fig. 199. — Disc harrow.

223. Harrows. — For the purpose of following the plow and breaking up the clods and smoothing the surface soil, harrows are used. Disc, spring-tooth, spike-tooth, and blade harrows or Acme, are the common types. In choosing a harrow one

FIG. 200. — Cutaway disc harrow.

must be governed largely by the character of work to be done and the type of soil on the farm.

Disc harrows. — As shown in Fig. 199, disc harrows are a series of round sharp discs mounted on a frame. When the harrow is propelled, these discs revolve and cut into the soil. They can be adjusted to cut at an angle or straight ahead. The

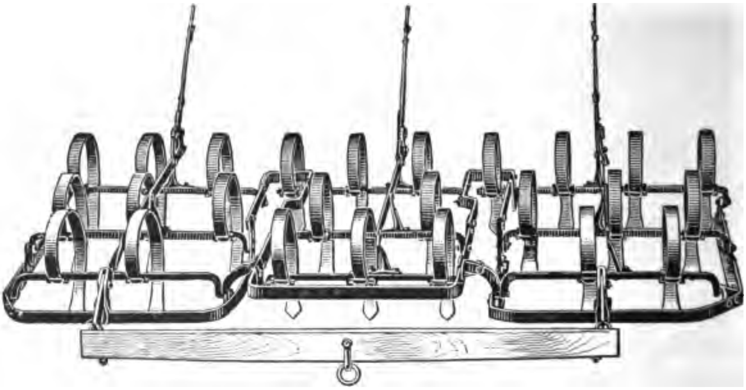

FIG. 201. — Spring-tooth harrow.

type illustrated in Fig. 200 is known as a spading or cutaway harrow. A harrow of this type gives a spading action which is efficient in cutting up clods and smoothing the soil and is especially useful on heavy soils.

Spring-tooth harrows. — In the spring-tooth harrows (Fig. 201) a series of flat, curved blades is fitted on a frame. The depth at which the blades enter the ground can be regulated by means of the levers. These harrows are especially efficient on stony ground or on soil that becomes compacted easily.

Fig. 202. — Spike-tooth harrow.

Spike-tooth harrows. — A much used type of harrow is the spike-tooth (Fig. 202). These harrows consist of a series of iron teeth fitted into a frame in such a way that they can be adjusted to stand in a vertical position or be slanted either forward or backward. They are useful for stirring and smoothing the soil.

Blade harrows. — The Acme, or blade harrow, which is shown in Fig. 203, consists of a row of blades that slice and turn the soil. This harrow pulverizes and smoothes the soil, espe-

cially when it is mellow and in good tilth; it is a very good type for the last harrowing preparatory to planting the seed.

224. Cultivators. — Crops like corn, cotton, and potatoes are tilled between the rows by cultivators, machines equipped

Fig. 203. — "Acme" harrow.

with small blades, shovels, or discs. Two types are on the market — one-horse cultivators and straddle-row cultivators.

One-horse cultivators. — In the one-horse type of cultivator (Fig. 204) the implement is propelled between the rows to be cultivated. This sort is generally used for cultivating small areas or when the corn or other crop has become too tall for the straddle-row type.

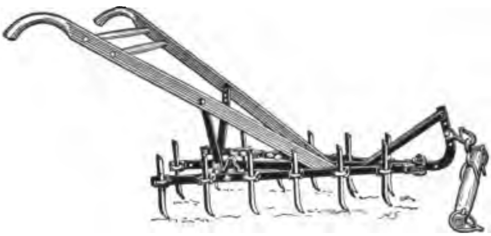

Fig. 204. — One-horse cultivator.

Straddle-row cultivators. — Both one-row (Fig. 205) and two-row (Fig. 206) straddle-row cultivators are manufactured. On the former the shovels or discs pass on both sides of a row, while in the latter two rows are cultivated

Fig. 205. — One-row straddle cultivator.

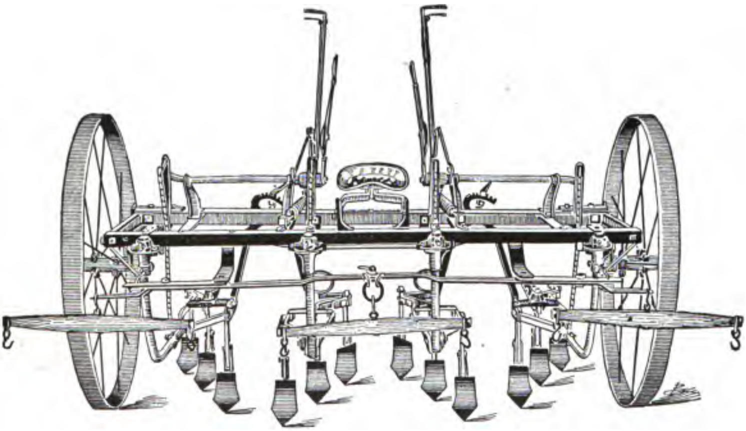

Fig. 206. — Two-row straddle cultivator.

at a time. With this implement, a man with three horses can cultivate twice as much ground in a given time as one man and two horses can with a single-row machine.

225. Weeders. — The implements known as weeders, one type of which is shown in Fig. 207, are provided with slender, flexible teeth and are used chiefly for cultivating the soil before the plants are above the ground and for a few days thereafter. They are effective in controlling weeds, which at this period of growth are small and easily killed.

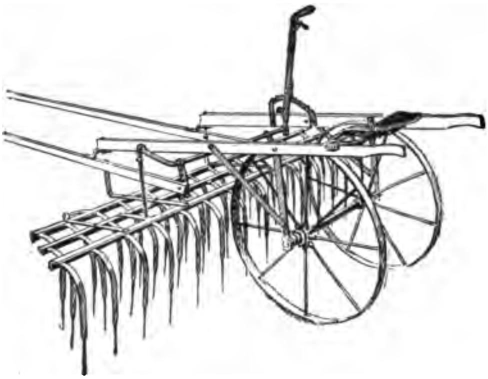

Fig. 207. — Weeder.

226. Planting implements. — Among the more common planting implements are broadcast seeders, grain drills, corn- and cotton-planters, potato-planters, and transplanters.

Broadcast seeders. — The broadcast seeders are employed chiefly for planting grass seed and, to a less extent, small grains. The knapsack seeder is the simplest form. A bag with the bottom opening into the distributing mechanism holds the seed. The bag is held in place by a strap over the operator's shoulder. The wheelbarrow seeder is essentially a long narrow box mounted on a frame and wheel and provided with handles like those of a wheelbarrow. In the bottom of the box are openings that are closed and opened by means of a vibrating rod that engages cogs attached to the side of the wheel when the seeder is pushed across the ground. The horse broadcast seeder, a third type, has much the appearance of a grain drill without the tubes that convey the grain to the ground. The grain is held in a long hopper box from which it is distributed through holes that are

opened and closed by the mechanism of the implement. The endgate seeder is a metal hopper that is attached to the endgate of a wagon. The seed is placed in the hopper and is distributed by means of a mechanism supplied with power from a sprocket attached to the wheel of the wagon.

Grain drills. — These are the implements generally employed for planting the cereal crops (Fig. 48). There are several types manufactured, but they all consist essentially of the wheels, the supporting frame, the hopper, the feeding mechanism, the tubes that convey the grain to the ground, the furrow openers, and the chains or wheels that cover the grain. In some localities drills are provided with fertilizer and grass-seed attachments.

Corn- and cotton-planters. — These machines are of two types — hand planters and horse-drawn planters. The former are

Fig. 208. — One-horse corn-planter.

used for corn and are employed where only small areas are planted or for replanting missing hills. The horse-drawn planters are either two-horse or one-horse. The two-horse planter drops the corn in hills or in drills at certain regular distances apart and plants two rows at a time (Fig. 39). The one-horse planter

(Fig. 208) plants one row at a time. Most one-horse planters can be adjusted to plant either corn or cotton.

In the bottom of the seed-boxes are revolving plates with holes or notches in them. As the plate revolves, the grain, or several grains, if planting in hills, drops into these holes or notches and is carried down into the soil.

Potato-planters. — These are very useful implements, a much-used type of which is shown in Fig. 88. The planters open a furrow, drop either whole or cut pieces at regular intervals, and cover the furrow with soil. Most potato-planters are equipped with fertilizer attachments.

Transplanters. — These implements (Fig. 93) are used extensively for the transplanting of seedlings of sweet potatoes, tobacco, celery, cabbage, and the like. They are provided with a tank or barrel for carrying water, a furrow opener, and a covering device. Two boys usually ride on the implement and hold the plants in an upright position until the soil is pressed around them. Water from the tank or barrel wets the soil around the plants as they are set.

227. Hay-harvesting machinery. — The usual hay-harvesting machines are mowers, rakes, tedders, loaders, stackers, harpoon forks, and slings.

Mowers. — On a mower (Fig. 56) there is a cutting bar that is protected with a series of fingers called guards. The cutter-bar is a set of triangular plates riveted to a bar of steel that moves back and forth over the guards. From his position on the seat the operator can raise and lower the cutter-bar to cut the grass at different heights. Mowers are either one-horse or two-horse; in the former type, they cut swaths three to three and one-half feet wide; the latter, from four and one-half to seven feet wide.

Rakes. — There are three general types of hay-rakes — sulky, side delivery, and sweep rakes (Fig. 60). Sulky rakes have a row of teeth that gather the hay from the swath; when a large enough quantity has been collected, it is dumped into

a windrow. Side-delivery rakes collect the hay and push it to one side in a continuous windrow by means of a system of moving forks. Sweep rakes have a series of long wooden fingers that are dragged along the ground. The implement is hitched between two horses that are kept some distance apart. When a load has been secured, the team is driven to a point where the hay is to be stacked.

Tedders. — Tedders are used for shaking up hay that has become wet or when there is a large yield that will not cure properly without being turned. They have a number of forks that turn the hay over as the implement is drawn over the ground.

Hay-loaders. — A labor-saving implement that is much used in handling hay is the loader (Fig. 59). One of these machines is attached to the rear of a hayrack and as the wagon is moved forward the hay is collected by a series of fingers and conveyed to the back end of the rack from which it is distributed on the load by hand.

Stackers. — There are several types of stackers in use. A common form is shown in Fig. 61. This equipment is almost indispensable where large quantities of hay are stacked each year.

Harpoon forks and slings. — For getting the hay into the barn or shed, harpoon forks or slings are used. These appliances are attached to the hay on a load, and by means of a rope and pulley the fork or sling with the hay holding to it is elevated into the barn and slid along a track to the point where it is to be deposited.

228. Small-grain, corn, and potato harvesters. — The implements used for harvesting small grains, corn, and potatoes have been described in the chapters dealing with these crops and need not be further explained.

229. Threshing machines. — In the threshing machine, (Fig. 52) the grain in the bundle is conveyed to a cylinder where it is removed from the head in passing between the cylinder and a concave. The grain sifts down through screens to an auger that delivers it from the machine. In its passage through

the screens, dust and chaff are blown away by an air blast from a fan. The straw passes over racks to the stacker.

230. Farm tractors. — A statement about farm machinery would be incomplete without mention of the modern farm tractor. In recent years, these machines have been much perfected and are now used on many farms. For the most part they are operated by gas engines, some form of petroleum being the fuel employed. Many of them burn kerosene and gasolene mixed; others burn only gasolene. Tractors can be secured in a variety of sizes, from those that can pull one or two plows to those capable of pulling a dozen or more (Fig. 196). The

FIG. 209. — A tractor pulling six seeders.

machines have many uses. In tillage work, they often haul plows and harrows at one operation. For planting, they can be arranged to haul a number of seeders (Fig. 209). For harvesting, they can be attached to a hay-loader (Fig. 59) or to several mowers (Fig. 56), or to binders (Fig. 49), and a wide swath can then be handled in one trip across the field. They are useful not only for pulling loads, but the engines can also be used to pump water, run the thresher (Fig. 210), saw wood, and the like. Tractors are made in two general styles, those with high wheels and those with a creeping tread. The latter are especially useful on muck ground. In price the tractors vary from a few hundred dollars to about $2500, the price being governed by the size and power of the machine.

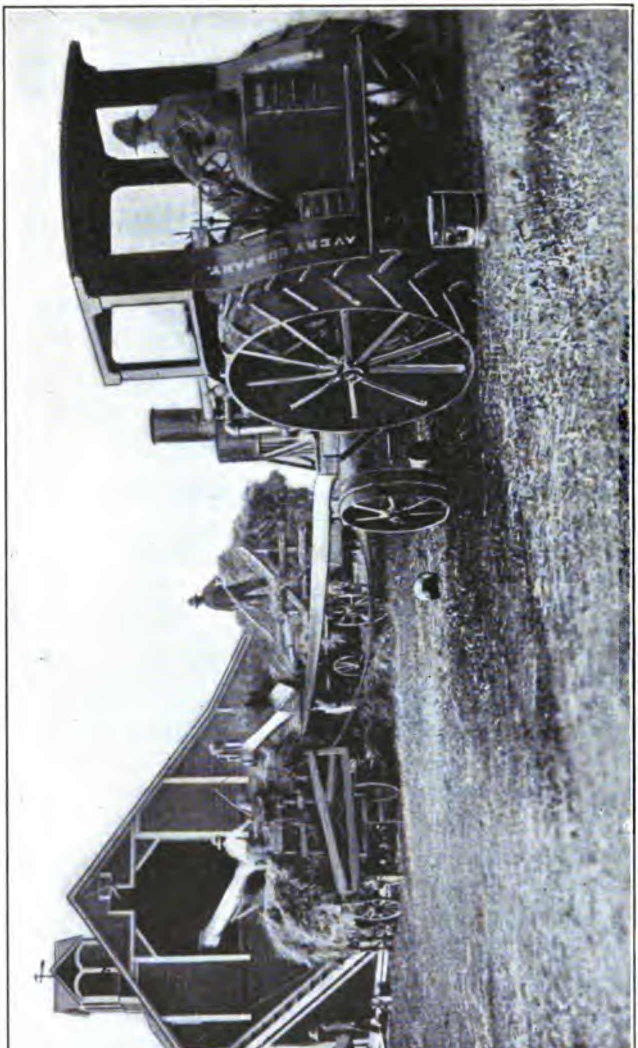

Fig. 210.— A tractor as a source of power for threshing.

QUESTIONS

1. In what ways can farm machinery be injured when in use?
2. Why should farm machinery when not in use be protected from the weather?
3. How can the life of grain binders on farms be trebled?
4. Why should a storage shed for machinery be part of the improvements of every farm?
5. Discuss the different types of harrows and tell for what particular use each is adapted.
6. For what are weeders used?
7. Name and describe the uses of three kinds of planting implements.
8. For what are hay tedders used?
9. State something of the importance of farm tractors.
10. What type of tractor is best for muck lands?

EXERCISES

1. **Machinery on farms.** — Visit several nearby farms, list the farm machinery on each place, and compute the cost of new machines of the same type. Find what percentage of the value of each farm a full set of new machinery would be.

2. **Setting up of machinery.** — Visit a dealer and have him set up several machines — a sulky plow, a mower, and a grain binder, for example. Study the different parts and determine their uses. Consult the printed instruction books for setting up machinery furnished by the manufacturer. These can be obtained from the dealers.

Write to the Advertising Department of the International Harvester Co., Chicago, for booklets of instructions dealing with the setting up and care of farm implements, including gas engines. Study these carefully.

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CHAPTER XXIII

FARM MANAGEMENT

The scope of farm management.
Farming as an occupation.
Choice of a region for farming.
Choice of the type of farming.
Choice of the farm.
Farm tenancy.
Laying out the fields.
Kinds of farm equipment.
Farm labor.
Planning a cropping system.
Farm accounts.
Farm records.
The marketing of farm products.

FARMING is a business as well as an occupation. The organization and management of it are subjects of first importance. It is not enough merely to be skillful in the raising of crops and animals. One must see that the income is greater than the outgo, and that the business proceeds with regularity. The farmer should know which of his operations and which of his products pay best. He should be able to eliminate the unprofitable activities, considering at the same time the necessity of maintaining a certain volume of business in order that he may retain labor and keep his capital moving. Market conditions must be understood. The good modern farmer is able to analyze his business, understanding the relationships between all the parts.

231. The scope of farm management. — This subject includes studies of such problems as the occupation of farming,

the choice of a region, the choice of the farm, decision on the type of operation, the form of tenure (if the farm is rented), the laying out of the fields, equipment, labor, cropping systems, accounts, records, and the marketing of products. Obviously not all of these subjects can be treated extensively in a one-volume book on general agriculture and in the following pages only brief statements of the various phases are given, but as an aid to those who desire to study the subject more extensively a full list of references is included.

232. Farming as an occupation. — There are many advantages as well as disadvantages in farming as an occupation. It is a stable business, not subject to serious disturbances of the financial world, it is healthful, independent, and when rightly conducted, fairly remunerative. On the other hand, it is more dependent on climatic and weather conditions than is any other occupation, and the average profits in farming are not large as compared with those of most other businesses.

233. Choice of a region for farming. — A prospective purchaser of a farm should consider carefully such factors as the character of the soil, the transportation facilities, the healthfulness of the region, the kind and quality of the farm labor available, the social and educational conditions, the kind of roads, the average value of farm lands, and the average crop yields for the important crops grown during a period of years.

234. Choice of the type of farming. — In selecting the kind of farming, one should be governed by the profitableness of the different types best suited to the region. His personal preference should be followed also, since one usually does well what he enjoys doing.

235. Choice of the farm. — With the region and the type of farming decided on, the next problem is the selection of the individual farm. Chief questions here involved are, How fertile is the soil? Is the topography of the farm desirable for the type of farming selected? Are the improvements satisfactory? Are the buildings located advantageously?

Are the fields well arranged and, if not, can they be arranged profitably? What are the distances to market, shipping station, school, and church? What kind of roads are those which must be traveled most frequently?

236. Farm tenancy. — Share tenancy and cash tenancy are both used in renting farms. The first is often preferred by renters, because it carries less risk. However, statistics show that cash tenancy is increasing in the United States. Economists usually consider it to be the better form. The character of contract between landlord and tenant is a serious problem to both. The proportion that each shall have will vary with the type of farming, the fertility of the soil, and the region where the farm is located.

237. Laying out the fields. — The fields should, as far as possible, be of the same size, for approximately the same area can then be devoted to a given crop each year. Often farms are cut up into small irregular-shaped fields. The problem of the farmer then is to arrange the fields by moving division lines, enlarging some, and reducing others. If possible the fields should be laid out in rectangles. All roads and lanes to and from the fields should follow this boundary. Permanent lanes should connect the pastures and stable yards so that the live-stock will travel to and from the pastures without a driver. Much time can be saved each year by this arrangement.

238. Kinds of farm equipment. — Real estate and personal property are included in farm equipment. Real estate consists of land, buildings, fences, drainage, irrigation, and water-supply systems. Personal property includes live-stock, implements and machinery, feed, seed, fertilizers, products for sale, fuel, and the like. As far as land is concerned, investigations have shown that large farms usually give a greater labor income than small farms. By labor income is meant the money a farmer has left after paying all the running expenses of the farm and the interest on the investment.

The Cornell Experiment Station has published in Bulletin 295 some very interesting figures secured from an agricultural survey made in the state. Table XVI gives the results found as to size of farm and labor income:

TABLE XVI

SIZE OF FARM AND LABOR INCOME

ACRES	LABOR INCOME IN DOLLARS
30 or less	168
31–60	254
61–100	373
101–150	436
151–200	635
over 200	947

239. Farm labor. — Both man and horse labor are included in this term. Regarding the efficiency of man labor, a very interesting condition was found by the Cornell Station in the survey referred to above. The results given in Table XVII show that on small farms man's labor is not utilized to the best advantage:

TABLE XVII

SIZE OF FARM AND EFFICIENCY OF MAN LABOR

ACRES IN FARM	ACRES FARMED WITH $100 WORTH OF MAN LABOR
30 or less	5
31–60	12
61–100	18
101–150	22
151–200	26
over 200	30

Horse labor on farms varies from six to sixteen cents an hour. Obviously the more a horse is used, the less he costs his owner for each hour. The term horse hour is used to indicate the work of a horse in one hour. Table XVIII shows the relation of the size of farms to the efficiency of horse labor as found in New York State:

TABLE XVIII

SIZE OF FARM AND EFFICIENCY OF HORSE LABOR

ACRES IN FARM	ACRES PER HORSE
30 or less	15
31–60	21
61–100	30
101–150	37
151–200	41
over 200	49

240. Planning a cropping system. — An individual problem for each farm is the planning of the cropping system. It involves a knowledge of the crops that are grown in the region, which ones do best in the different rotations, the money returns that may be expected from each, the effects of the different crops on the soil, and other similar factors.

241. Farm accounts. — In conducting a farm business, it is necessary to know whether or not the business is profitable, how much is made or lost annually on each crop or class of live-stock, and how to improve the methods so as to make more money. These facts a farmer can know only by keeping a set of books. The keeping of farm accounts is not as difficult as it may seem, nor does it necessarily involve an outlay of much time. One of the best and simplest systems of farm accounts has been developed by G. F. Warren, the principles of which are published in his book, *Farm Management*. Also, in Farmers' Bulletin 572 C. E. Ladd describes this system after having given it a thorough trial for three years with a number of farmers working under his supervision.

The time to keep a set of books by this system averages about five minutes daily and a number of hours at the end of the year to close the set of books. No bookkeeping knowledge is necessary to take care of a set of books by this method. In fact Ladd found that in some instances a knowledge of bookkeeping proved to be detrimental, since trained bookkeepers have a tendency to insert technicalities and com-

plex entries that are out of place in such a system of farm accounts.

Farmers' Bulletin 782, *The Use of a Diary for Farm Accounts*, can be utilized in making a simple set of books. This method has proved satisfactory to many farmers. Farmers' Bulletin 511, *Farm Bookkeeping*, is another excellent publication that is of value in working up a set of farm accounts.

242. Farm records. — Differing somewhat from farm accounts, farm records include such items as the yearly records of production of the dairy herd, breeding records of all classes of live-stock, feeding records, lists of feeds and other supplies, weather records, seeding dates, and reports of the last killing frosts in spring and first killing frost in the fall. The keeping of such records requires but little time and this time is well spent.

243. The marketing of farm products. — A detail of farm management that should receive more attention from the average American farmer is the marketing of his products. As a rule farmers in this country have produced their products better than they have sold them. Selling goods of any kind requires business ability. Much has been said about the proper grading and packing of produce, but one has only to visit almost any market where produce is sold to find unsorted and unattractive potatoes and apples side by side with those packed and sorted properly. This means that all farmers have not learned that it pays to put up these products correctly.

Another detail that must be considered in marketing is whether or not crops that shrink in storage, like corn and potatoes, would better be sold in the fall or spring. The Iowa Station found in tests that ran for eight years that the shrinkage on corn was: Dec. 1, 5.2 per cent; Jan. 1, 6.9 per cent; Feb. 1, 7.5 per cent; March 1, 7.8 per cent; April 1, 9.7 per cent; May 1, 12.8 per cent; June 1, 14.7 per cent; July 1, 16.3 per cent; August 1, 17.3 per cent; September 1, 17.8 per cent; October 1, 18.2 per cent.

Potatoes on the average will shrink 6 per cent from October to February and 10 per cent from October to May. These figures are useful as guides in determining whether a farmer should sell the products in the fall or in the spring, considering the average prices received.

QUESTIONS

1. What is meant by the term farm management?
2. State some of the advantages and the disadvantages of farming as a business.
3. In selecting a region for farming what factors should be considered?
4. Why should the different fields of a farm be of nearly the same size?
5. What is the advantage of having a permanent lane connect the pasture and the stable yard?
6. Why should a farmer keep a set of account books?
7. What publications can a person secure free that will aid him in making up a system of farm accounts for his own farm?
8. What are farm records and how do they differ from accounts?
9. Why should farm products be graded and packed carefully?
10. How much do potatoes usually shrink from October to February?

EXERCISES

1. **Farm inventory.** — Make a farm inventory of some farm in your vicinity using as a guide the inventory given herewith which is from Farmers' Bulletin 511.
2. **Choice of a farm.** — Choose some farm in the neighborhood as one you intend to purchase and answer the questions as given in paragraph 235.
3. **Farm accounts.** — Let each pupil, as far as practicable, adopt either Farmers' Bulletin 572 or 782, and work up a set of farm accounts for his father's or a neighbor's farm.
4. **Lay-out of a farm.** — Draw a map of a farm that has irregular-shaped fields. Redraw, with fields arranged so that they are rectangular and nearly of the same size.
5. **Cropping system of a farm.** — Plan a cropping system of a farm taking into consideration the factors listed in paragraph 240.

Sample Farm Inventory: Farm of ———

Property	April 1, 1911				April 1, 1912			
	No.	Rate	Valuation		No.	Rate	Valuation	
REAL ESTATE								
Farm of 180 acres (155 tillable), including buildings (dwelling $1,600, barns $1,800, other buildings $600), fences, and other improvements . . .	—	—	—	$13,500.00	—	—	—	$13,500.00
LIVE-STOCK								
Dairy cattle:								
Cows, dry and in milk	24	$50.00	$1,200.00		26	$50.00	$1,300.00	
Bull	1	—	50.00		1	—	45.00	
Calves	6	14.00	84.00		8	15.00	120.00	
Two-year-olds . . .	4	28.00	112.00		6	20.00	120.00	
Total value of dairy cattle	—	—	—	1,446.00	—	—	—	1,585.00
Hogs:								
Brood sows	2	22.00	44.00		2	21.00	42.00	
Pigs	8	4.00	32.00		6	3.00	18.00	
Total value of hogs	—	—	—	76.00	—	—	—	60.00
Horses:								
Horse, Jim, 7 years old	1	—	200.00		1	—	180.00	
Team, Nell and Bess, 5 and 6 years old . .	1	—	425.00		1	—	425.00	
Team, Jack and Prince, 6 and 7 years old . .	1	—	400.00		1	—	400.00	
Colt, 1 year old . .	1	—	75.00		1	—	145.00	
Total value of horses	—	—	—	1,100.00	—	—	—	1,150.00
Poultry:								
Hens	160	0.60	96.00		125	0.60	75.00	
Roosters	5	1.00	5.00		4	1.00	4.00	
Turkeys	2	3.00	6.00		3	3.00	9.00	
Total value of poultry	—	—	—	107.00	—	—	—	88.00
Total value of live-stock	—	—	—	2,729.00	—	—	—	2,883.00
MACHINERY AND TOOLS								
Grain binder	1	—	90.00		1	—	82.00	
Sulky plows	2	45.00	90.00		2	41.00	82.00	
Disc harrow . . .	2	28.00	56.00		2	25.00	50.00	
Mower	1	—	35.00		1	—	30.00	
Hay rake	1	—	20.00		1	—	19.00	
(List all items of farm machines, wagons, harness, and small tools.)								
Total investment in machinery and tools (not all listed here)	—	—	—	475.00	—	—	—	461.00

Sample Farm Inventory (*Continued*)

Property		April 1, 1911 No.	Rate	Valuation		April 1, 1912 No.	Rate	Valuation	
FEED AND SUPPLIES									
Farm products:									
Corn	bushels	80	$.60	$48.00		125	$.60	$75.00	
Oats	do	200	.42	84.00		90	.50	45.00	
Potatoes	do	40	.75	30.00		80	.60	48.00	
Hay, timothy	tons	10	16.00	160.00		20	15.00	300.00	
Hay, mixed	do	5	12.00	60.00		4	12.00	48.00	
Silage	do	40	4.00	160.00		40	4.00	160.00	
Bran	do	0½	—	15.00		—	—	—	
Mixed feed	do	1	—	31.00		2½	30.00	75.00	
Seed oats	do	30	.80	24.00		35	.80	28.00	
Seed potatoes	do	45	.80	36.00		50	1.00	50.00	
Seed corn	do	3	2.00	6.00		3	2.00	6.00	
Cement	sacks	4	.50	2.00		—	—	—	
Twine	pounds	20	.10	2.00		10	.10	1.00	
Total value of feed and supplies		—	—	—	658.00	—	—	—	836.00
BILLS RECEIVABLE									
J. A. Brown, hay	tons	2	13.00	26.00					
R. S. Jones, potatoes	bushels	40	.50	20.00					
Total		—	—	—	46.00				
CASH									
On hand		—	—	90.00		—	—	210.00	
In bank		—	—	580.00		—	—	1,938.00	
Total		—	—	—	670.00	—	—	—	2,148.00
BILLS PAYABLE									
Farm mortgage		—	—	—	2,000.00	—	—	—	1,500.00
SUMMARY									
Real estate		—	—	13,500.00		—	—	13,500.00	
Live-stock		—	—	2,729.00		—	—	2,883.00	
Machinery and tools		—	—	475.00		—	—	461.00	
Feed and supplies		—	—	658.00		—	—	836.00	
Bills receivable		—	—	46.00		—	—	—	
Cash on hand and in bank		—	—	670.00		—	—	2,148.00	
Total investment		—	—	—	18,078.00	—	—	—	19,828.00
Bills payable		—	—	—	2,000.00	—	—	—	1,500.00
Net worth		—	—	—	16,078.00	—	—	—	18,328.00
Increase in inventory, $2,250.									

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Farmers' Bulletin 572, *A System of Farm Cost Accounting.*
Farmers' Bulletin 782, *Use of a Diary for Farm Accounts.*
Farmers' Bulletin 551, *Farm Bookkeeping.*
Farmers' Bulletin 746, *The Farmer's Income.*
Farmers' Bulletin 635, *What the Farm Contributes Directly to the Farmer's Living.*
Farmers' Bulletin 614, *A Corn-Belt Farming System Which Saves Harvest Labor by Hogging Down Crops.*
Farmers' Bulletin 719, *An Economic Study of the Farm Tractor in the Corn Belt.*
Farmers' Bulletin 312, *A Successful Southern Hay Farm.*
Farmers' Bulletin 326, *Building up a Run-down Cotton Plantation.*
Farmers' Bulletin 370, *Replanning a Farm for Profit.*
Farmers' Bulletin 432, *How a City Family Managed a Farm.*
U. S. Dept. of Agriculture Bulletin 341, *Farm Management Practice of Chester County, Pa.*
U. S. Dept. of Agriculture Bulletin 41, *A Farm-Management Survey of Three Representative Areas in Indiana, Illinois, and Iowa.*
U. S. Dept. of Agriculture Yearbook, Separate 715, *Farm Tenantry in the United States.*

APPENDIX

DIRECTORY OF THE U. S. DEPARTMENT OF AGRICULTURE

Secretary of Agriculture.

Executive and administrative head of the department.

Assistant Secretaries of Agriculture.

Assist in directing the work of the department. In the absence of the Secretary one becomes Acting Secretary.

Solicitor.

Is legal adviser to the Secretary and the heads of the several branches of the department, conducts its legal work, and represents it in all legal matters.

Office of Farm Management.

Studies the details of farm practice from a business standpoint, with a view to determining the most efficient methods of operation.

Weather Bureau.

Conducts meteorological investigations; issues weather maps; handles all work relating to climate, storm warnings, frost warnings, etc.

Forest Service.

Administers the national forests and develops use of their resources; directs all research work relating to forestry and forest utilization.

Bureau of Animal Industry.

Studies and gives information regarding live-stock; conducts the meat-inspection and quarantine work.

Bureau of Plant Industry.

Investigates problems relating to plants and plant industries.

Bureau of Chemistry.

Enforces the Food and Drugs Act; investigates questions of agricultural chemistry.

Bureau of Soils.

Surveys and maps the soils and investigates the fertilizer resources of the United States.

Bureau of Entomology.

Studies insects in their relation to agriculture.

Bureau of Biological Survey.

Studies wild birds and animals, their distribution, habits, and relations to agriculture; administers the Federal bird and game reservations and the Federal laws protecting game and regulating the importation of birds and animals. Controls noxious mammals and experiments in fur farming.

Bureau of Crop Estimates.

Collects crop statistics; gathers and collates general agricultural statistics; issues crop reports and forecasts.

Office of Public Roads and Rural Engineering.

Studies and supplies information regarding road making, road management, road maintenance, farm irrigation, farm drainage, and rural engineering and architecture.

States Relations Service.

Supervises the use of Federal funds for agricultural experiment stations and agricultural extension work; investigates agricultural education, and food, dietetics, clothing, and household equipment and management.

Office of Markets and Rural Organizations.

Investigates problems pertaining to marketing and distribution of farm products and organizing rural communities for marketing, rural credit, and other purposes. Enforces Cotton-Futures Act.

Federal Horticultural Board.

Assists in the enforcement of the Plant Quarantine Act of August 20, 1912.

Insecticide and Fungicide Board.

Assists in the enforcement of the Insecticide Act of 1910.

ADDRESSES OF THE STATE EXPERIMENT STATIONS

Alabama —
- College of Agriculture and Experiment Station, Auburn.
- Canebrake Station, Uniontown.
- Tuskegee Station, Tuskegee.

Alaska — Sitka.

Arizona — Tucson.

Arkansas — Fayetteville.

California — Berkeley.

Colorado — Fort Collins.

Connecticut —
- State Station, New Haven.
- Agricultural College and Storrs Experiment Station—Storrs.

Delaware — Newark.

Florida — Gainesville.

Georgia — Experiment.

Hawaii —
- Federal Station — Honolulu.
- Sugar Planters' Station — Honolulu.

Idaho — Moscow.

Illinois — Urbana.

Indiana — Lafayette.

Iowa — Ames.
Kansas — Manhattan.
Kentucky — Lexington.
Louisiana — Baton Rouge.
Maine — Orono.
Maryland — College Park.
Massachusetts — Amherst.
Michigan — East Lansing.
Minnesota — St. Anthony Park, St. Paul.
Mississippi — Agricultural College.
Missouri —
  College Station — Columbia.
  Fruit Station — Mountain Grove.
Montana — Bozeman.
Nebraska — Lincoln.
Nevada — Reno.
New Hampshire — Durham.
New Jersey — New Brunswick.
New Mexico — Agricultural College.
New York —
  State Station — Geneva.
  College of Agriculture and Cornell Experiment Station — Ithaca.
North Carolina —
  College Station — West Raleigh.
  State Station — Raleigh.
North Dakota — Agricultural College.
Ohio —
  Experiment Station — Wooster.
  College of Agriculture — Columbus.
Oklahoma — Stillwater.
Oregon — Corvallis.
Pennsylvania — State College.
Porto Rico — Mayaguez.
Rhode Island — Kingston.
South Carolina — Clemson College.
South Dakota — Brookings.
Tennessee — Knoxville.
Texas — College Station.
Utah — Logan.
Vermont — Burlington.
Virginia — Blacksburg.
Washington — Pullman.
West Virginia — Morgantown.
Wisconsin — Madison.
Wyoming — Laramie.

THE PUBLICATIONS OF THE DEPARTMENT OF AGRICULTURE [1]

A new classification of the publications of the Department of Agriculture was adopted July 1, 1913, as follows:

Department Bulletins :

The popular matter heretofore published in the bulletins and circulars of the various Bureaus, Divisions, and Offices is now published in the Departmental series of bulletins, which contain a popular discussion of the investigations of the Department. A sub-series of these bulle-

[1] The author is indebted to Mr. Joseph A. Arnold, Editor and Chief, Division of Publications, United States Department of Agriculture, for the statements that follow.

tins, known as Professional Papers, is issued, which contain discussions of the work of a professional or semi-professional nature, dealing with crops, animals, and similar matter, which, though sometimes handled in a popular way, may be presented in a professional or technical form. These are generally of octavo size, illustrated by plates or text figures or both, and are generally printed without cover, title page, table of contents, or index, and are issued in editions of 2500 to several thousand, according to the subject, the nature of the demand, and the need for wide distribution of the information. Copies of these bulletins are distributed free to all who apply for them, as long as the supply lasts. When no copies are available, applicants are referred to the Superintendent of Documents, Government Printing Office, who has them for sale at a nominal price, in accordance with the provisions of law.

Serial Publications :

This series comprises (*a*) The Journal of Agricultural Research, in which are included scientific and technical articles giving the results of investigations of scientific experiments by the Department. The Journal is published weekly, and is distributed free only to agricultural colleges, technical schools, experiment station libraries, State universities, Government depositories, and to such institutions as make suitable exchanges with the Department. Further distribution is by purchase from the Superintendent of Documents, Government Printing Office, the subscription price being $3.00 a year. The Journal is royal octavo in size, and varies from 20 to 48 pages. (*b*) Experiment Station Record. Published monthly and contains abstracts and comments on the scientific work bearing on agriculture issued by the agricultural experiment stations and other institutions. It is distributed free to persons engaged in scientific investigations of agricultural subjects, libraries of experiment stations, agricultural colleges, and collaborators and coöperators with a Department. Miscellaneous applicants may procure it by purchase from the Superintendent of Documents, the subscription price being $1.00 a volume, two volumes being issued a year, or 15 cents per single copy. (*c*) The Monthly Crop Report, issued according to law. It contains statistics with regard to condition, production, and yield of crops, and the production and value of farm animals. It is quarto in size, contains 8 to 12 pages, and is sent to all who are interested. (*d*) The Weekly News Letter. A weekly publication consisting of from 4 to 8 pages. Published for the information of the employees of the Department, and sent to correspondents of the Department. It can be purchased from the Superintendent of Documents, who has it for sale at 50 cents a year. (*e*) The Monthly List of Publications. A four-page leaflet, issued after the first of each

month. It contains a list by numbers and titles of the publications issued during the preceding month. It gives the title, author, and number of pages of each publication, and the price at which it may be obtained from the Superintendent of Documents after the Department's supply is exhausted, together with a short sketch describing the character of the bulletin and the section of the country to which it is particularly applicable. It is sent free to all who apply for it. (*f*) The Monthly Weather Review. This is a quarto-sized publication, consisting of 12 numbers to the volume, and is for sale by the Superintendent of Documents, the subscription price being $2.50 a year.

Congressional Publications :

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